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BULLETIN NO. 30, NEW SERIES.

U. S. DEPARTMENT OF AGRICULTURE,

DIVISION OF ENTOMOLOGY.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE DIVISION OF ENTOMOLOGY.

V.

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L. O. HOWARD,

ENTOMOLOGIST.

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1901.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Division of Entomology,
Washington, D. C., July 25, 1901.

Sir: I have the honor to transmit herewith the manuscript of a bulletin which contains matter similar to that published in Bulletins 7, 10, 18, and 22 of the new series, namely, miscellaneous articles and notes which are too short for separate publication, but which are of sufficient importance to render an early printing desirable. I recommend the publication of this manuscript as Bulletin No. 30, new series, of this Division.

Respectfully,

L. O. Howard,
Entomologist.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.

THE DIFFERENTIAL GRASSHOPPER IN THE MISSISSIPPI DELTA—OTHER COMMON SPECIES (illustrated) ..... *H. A. Morgan* .. 7

SOME INSECTICIDE EXPERIMENTS ..... *C. L. Marlatt* .. 33

THE CARRIAGE OF DISEASE BY FLIES (illustrated) ..... *L. O. Howard* .. 39

THE GREEN CLOVER WORM (illustrated) ..... *F. H. Chittenden* .. 45

REPORT UPON AN INVESTIGATION OF THE CODLING MOTH IN IDAHO IN 1900. *C. B. Simpson* .. 51

INSECTS AND THE WEATHER DURING THE SEASON OF 1900 ..... *F. H. Chittenden* .. 63

ON THE HABITS OF ENTILIA SINUATA (illustrated) ..... *L. O. Howard* .. 75

FUMIGATION WITH CARBON BISULPHIDE ..... *W. E. Hinds* .. 78

GENERAL NOTES 82

Ichneumonid Parasites of the Sugar-cane Borers in the Island of Reunion (p. 82); Insects from British Honduras (p. 82); Notes from the Philippines (p. 83); Miscellaneous Notes from Kansas (p. 84); Unusual Injury by Cutting Ants in Texas (p. 85); Injurious Moths Attracted to Lights in Autumn (p. 85); The Augumois Grain Moth in Pennsylvania (p. 86); Use of Sulphur as a Remedy for the Indian-meal Moth (p. 88); Fuller's Rose Beetle in the Hawaiian Islands (p. 88); Singular Instances of Attack on Human Beings by Insects (p. 90); Efficiency of the Two-spotted Ladybird as a Plant-Louse Destroyer (p. 90); The Overflow Bug Again (p. 90); A Remedy for Flea-Beetles in California Vineyards (p. 91); Injury to Rustic Cedar Fences and Summerhouses by Borers (p. 91); Ineffectiveness of Kerosene Emulsion Against White Grubs (p. 92); A New Enemy of Figs in Mexico (p. 93); On the Food Habits of the Papabotte (p. 93); On the Insectivorous Habits of Squirrels (p. 94); Insect Injury to Binding Twine (p. 94); To Rid Cats of Fleas (p. 94); A New Remedy Against Phylloxera (p. 95); A Note on the Glassy-Winged Sharpshooter (p. 95); On the Alleged Immunity of Redwood to Attack by Termites (p. 95); The Bran-Arsenic Mash Against Grasshoppers in Texas (p. 96); Termites in Mexico (p. 96); An Entomological Service in Mexico (p. 96).

NOTES FROM CORRESPONDENCE 97

Remedies Against Ants (p. 97); A Troublesome Ant (p. 97); Migration of the Western Willow Flea-beetle (p. 97); The Grapevine Fidia in Illinois (p. 97); Beetles Occurring about Smelting Works (p. 97); A Snout-Beetle Injuring Guava in Porto Rico (p. 97); Reported Injury by the Oil Beetle, *Meloë impressus* Kirby (p. 98); Injury to Apple Leaves by the Caterpillar of *Euclea pænulata* Clem. (p. 98); Injury by *Lygus invitus* Say (p. 98); The Box-Elder Plant-Bug (*Leptocoris trivittatus* Say) in Iowa (p. 98); A European Plant-Louse Introduced in Massachusetts (p. 98).

ILLUSTRATIONS.

PLATES.

		Page.
Pl. I.	Trees sprayed with crude petroleum and trees sprayed with lime, sulphur, and salt wash	34
II.	Plum tree sprayed with heavy lime wash	38

TEXT FIGURES.

Fig. 1.	*Melanoplus differentialis*	11
2.	*Melanoplus differentialis:* ootheca or egg case	12
3.	Grasshopper eggs exposed by cultivation	15
4.	Patterson tarred sheet	18
5.	Hopperdozer	19
6.	*Trombidium locustarum:* female, newly hatched larva, egg, eggshells	22
7.	*Trombidium locustarum:* mature larva, pupa, male and female adult	23
8.	*Macrobasis unicolor:* female, male antenna	23
9.	*Sarcophaga sarracenex:* larva, puparium, adult	24
10.	*Sarcophaga assidua:* larva, puparium, adult	25
11.	*Euphorocera claripennis:* adult, puparium	25
12.	*Lucilia cæsar*	26
13.	*Schistocerca americana:* adult	26
14.	*Schistocerca obscura:* adult	27
15.	*Schistocerca obscura:* fifth stage	27
16.	*Dictyophorus reticulatus:* adult	28
17.	*Dictyophorus reticulatus:* egg sac	29
18.	*Orchelimum agile:* adult	30
19.	*Orchelimum agile:* eggs of, in cotton stalk	30
20.	*Musca domestica:* puparium, adult, larva	41
21.	*Drosophila ampelophila:* adult, puparium, larva	42
22.	*Homalomyia brevis:* female, male, larva	43
23.	*Stomoxys calcitrans:* adult, larva, puparium	43
24.	*Scatophaga furcata:* male	44
25.	*Morellia micans:* adult, puparium	44
26.	*Plathypena scabra:* moth, wings expanded and wings folded, larva, egg	46
27.	*Entilia sinuata:* adult, nymph	76
28.	*Entilia sinuata:* developmental stages	77
29.	*Ophion antankarus:* wings of	82

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE DIVISION OF ENTOMOLOGY.

V.

THE DIFFERENTIAL GRASSHOPPER IN THE MISSISSIPPI DELTA—OTHER COMMON SPECIES.

By H. A. Morgan.

INTRODUCTION.

The differential grasshopper has been known to occur in the Upper Mississippi Valley for many years, but its appearance in devastating numbers as far south as the State of Mississippi is of recent date. In 1890 and 1891 crevasses occurred on the east side of the Mississippi River between Rolling Fork and Coahoma, Miss. Plantations in this delta region around Hampton Station, on the Riverside Division of the Yazoo and Mississippi Valley Railroad, were inundated, and for a few years following grasshoppers appeared in destructive numbers; "Linden," "Glen Willow," and "Richland" plantations suffering the most. Though these attacks were more or less local and no urgent complaints were heard, the outbreak following an overflow of 1897 was attended by more serious and widespread injury. The results of an investigation of this latter outbreak, made during 1899 and 1900, are discussed in this article.

In Bolivar County, Miss., is located the famous Dahomy property (19,000 acres), which is perhaps the largest cotton plantation in the South. Upon this property, about 1 mile east of the Yazoo and Mississippi Valley Railroad, a basin consisting of about 300 acres exists. After the crevasse water of 1897 receded this basin remained flooded. The crevasses opening as late as the 28th and 30th of March and the water remaining upon the property for at least six weeks so delayed planting that no attempt was made to include the basin in the cultivation of 1897. It became a forest of weeds and a most favorable feeding and breeding ground for so sturdy and prolific a species of grasshopper as the differential. The spring of 1898 was favorable for early planting, and the basin, with the rest of the property, was ploughed,

put in a state of thorough cultivation, and planted. Early in June rows of cotton adjacent to the ditches draining this basin were damaged by grasshoppers, but little attention was paid to the particular species, as the area attacked was considered insignificant. Nothing was done to suppress this miniature outbreak or to avoid a repetition of it the following year, but the situation was no more threatening than that witnessed on neighboring plantations a few years previous.

The vigor of the attack in 1899, spreading perhaps from different infesting areas for hundreds of miles, was unexpected, and no effort was made to check the young grasshoppers at the time when remedial measures are more or less effective. So little attention was paid to the grasshopper situation that the early molts had taken place and the nymphs had reached a considerable size before a condition almost equal to a plague was realized.

The ravages upon Dahomy began in and around the basin and spread in a northwesterly direction until more than 5,000 acres of corn and cotton were involved.

Mr. P. M. Harding, representing the owners of Dahomy, outlined in the following letter to the Hon. James Wilson, Secretary of Agriculture, the gravity of the situation:

VICKSBURG, MISS., *July 6, 1899.*

DEAR SIR: I sent you by express yesterday from Benoit, Miss., some specimens of corn and cotton stalks and other vegetation, together with a box of grasshoppers, for your examination, and in the hope that you may render us some immediate assistance in the matter of destroying the grasshoppers that are devouring our crops of cotton, corn, oats, millet, and pease.

I beg to explain that I represent the Equitable Company of New York, which has recently acquired the large plantations formerly owned by the late Mr. James S. Richardson, including what is known as the Dahomy property in Bolivar County, Miss., which consists of about 19,000 acres of land, with between 9,000 and 10,000 acres in cultivation, and which is the largest cotton plantation in the South. It is on this property that the grasshoppers are doing the greatest damage, and unless their ravages are terminated by some means at a very early date I am satisfied they will entirely eat up the crops.

The grasshoppers made their appearance on Dahomy early in the spring, feeding first on the vegetation along the sloughs, the edge of the timber, and on the ditch banks. I was on this property about three weeks ago, and found that while they were rapidly increasing in numbers they had done but little damage to the crops, eating a little young cotton at the end of the rows along the ditch banks, and here and there we saw where they had cut some of the stalks of corn at the ends of the rows, and they were about that time beginning to feed on the oats. My managers have been reporting from time to time of their increase, but not until ten days ago did they report that they were going away from the ditch banks and completely covering the fields.

I have just returned from this property, and beg to give you my observations concerning the damage done to the various crops, as follows:

Cotton.—They have totally destroyed 300 acres. What I mean by totally destroying this acreage is that they have eaten all of the foliage off of the stalks, killing the stalk completely, and on a large part of this 300 acres there is not a vestige of stalk left, the ground being as bare as when it was first broken up for planting.

There are 2,000 acres more that they are working on now and have damaged 50 per cent. They are eating the leaves and the forms or blooms, as well as the tender bark from off the stalks and limbs, causing the limbs and stalks to shrivel up and die, and if they continue their work ten days longer they will have completely destroyed the cotton on these 2,000 acres.

On the remaining acreage in cotton, there being a total of something over 5,000 acres, they have not as yet done any great damage, but it all lies contiguous and there are grasshoppers on every acre of it, though not in sufficient quantities thus far to do much harm.

Corn crop.—There are 150 acres totally destroyed, by which I mean to say that the grasshoppers have eaten the tassel and the silk from around the ear completely, which means that under these circumstances the corn can not mature. They follow the silk down into the ear and eat out the tender cob; they have also eaten holes through the shucks, and clear through the ears of corn, and in addition are stripping the corn of the blade. In riding through a patch of 100 acres I found the grasshoppers on the stalks all the way from the ground to the top, as well as on the blades, and numbers of them on the tassels. I counted as many as 30 on the tassels and 15 on some of the blades, averaging probably 25 to 50 grasshoppers to each stalk.

In addition to the corn that they have completely destroyed there are about 300 acres that they have partially destroyed, and there are some grasshoppers in smaller quantities in all of the balance, which balance has been damaged but little thus far, though if they continue their ravages to the same extent that they have been working for the past two weeks they will ruin it all.

Oats.—Our oat crops before we cut them were damaged fully 50 per cent. The grasshoppers ate the blade and then cut off the head, leaving the ground perfectly white in places.

Millet.—The millet is literally alive with grasshoppers, but as it is very thick the damage does not seem to be so great, though if they continue their work they will doubtless ruin it.

Sorghum.—While the sorghum patches are filled with grasshoppers I can not see that they have done any great amount of damage; only here and there we found where the blades had been cut.

In the foregoing I have tried to give you a thoroughly correct idea from my own personal observation of the damage done on this property. As far as I have been able to ascertain the grasshoppers have not done much damage south of the town of Benoit, which is in Bolivar County, though in the northern part of the county I am advised that they have eaten up whole crops as they are now doing on Dahomy. Mr. Charles Scott, of Rosedale, informs me that they are devouring his crops as well as other crops in his neighborhood. They are also to be found along the ditch banks on the plantations throughout Washington County, though they have thus far done but little injury to the crops there.

I have written to the agricultural colleges in this State and Louisiana endeavoring to get them to send some one to look over the situation and devise some means for preventing further damage, if possible, as well as to put a stop to their ravages in future, but unfortunately the entomologists of both colleges are absent, one of them being in San Francisco and another at Cornell University.

I now write to ask that you send some one to investigate the matter with a view of applying a remedy immediately, or instructing me what to do in order to save a part of our crops this year.

Both colleges have sent me their formulæ for preparing a mixture of poison, consisting of paris green with bran and molasses or sweetened water, and distributing it through the fields. We have carried out the directions and find that the grass-

hoppers eat the mixture voraciously, but it does not seem to kill them. We find a very few dead grasshoppers, but practically the mixture does them no harm. We have dusted the grass and weeds in the ditches with the raw, unmixed paris green, where the grasshoppers were in great numbers, and upon examination next morning we would find a few dead ones at the bottom of the ditch, but just as many living ones feeding on the grass as before we sprinkled it with paris green; hence it seems that this poison is not efficacious.

I feel that the matter is one of great importance to the cotton planters of this section, and I sincerely trust that you will send out one of your best men to Vicksburg and I will take pleasure in going with him to this property and taking care of him while there, rendering every facility for destroying the pests.

I am advised that in 1897 the first was seen of the grasshoppers in this locality in any quantities, and that year they did but little damage, eating some cotton or corn at the ends of the rows along the ditch banks. In 1898 they did more damage along the ditch banks on this particular property, injuring probably one or two hundred acres of cotton. However, they did not destroy any of it outright, while this year they literally cover the larger part of the property, and in the foregoing letter I have endeavored to give a correct estimate of the damage done to date.

It is not the same species that we have had with us all along, and we are disposed to fear that perhaps the grasshopper of the West or some other similar species is now visiting us.

Very respectfully, P. M. Harding.

Hon. James Wilson,
Secretary of Agriculture, Washington, D. C.

Mr. Harding's letter was referred to the Division of Entomology, and Dr. L. O. Howard made the following reply:

July 11, 1899.

Dear Sir: Your letter of the 6th instant, addressed to the honorable Secretary of Agriculture, duly received and referred to this Division for attention. I wish to acknowledge also the receipt of two large packages, one of corn and one of cotton, sent from Benoit, Miss. An examination shows that the grasshopper which is depredating so seriously on cotton, corn, etc., in Mississippi proves to be what is known as the differential locust (*Melanoplus differentialis* Thos.). This is a common native species of grasshopper, occurring every year throughout the Mississippi Valley. It feeds normally on grasses, such as timothy, alfalfa, and clover, as well as the native grasses, and is not especially an enemy of cereal crops or cotton. In Mississippi, however, it has been known to multiply excessively in lowlands and waste grass patches along ditches, and so forth, and to migrate from such situations into cotton fields and neighboring cornfields. This habit, therefore, is unusual and peculiar, and dependent on very favorable conditions, which have led to the unusual multiplication of the grasshopper. The habits of this species have been detailed in three of our bulletins relating to grasshoppers or locusts. I am sending you a copy of each of the three, namely, Nos. 25, 27, and 28, old series, giving habits of different species of grasshoppers and the means of control. The differential locust is discussed in Bulletin No. 25 on page 30, in Bulletin No. 27 on pages 62 and 63, and in Bulletin No. 28 on pages 15 to 17. I refer you particularly to the advice as to remedies mentioned under this species in Bulletin No. 27. After the locusts have become winged, as many of them are at present, it is impracticable to attempt any of the ordinary means of control, such as collecting with hopperdozers or driving them into ditches, and so forth, and the only remedy is in the use of poisons. I do not believe the bran-arsenic mash to be practicable over the large areas infested, in view of the scattered condition of the locust. It will doubtless be of more or less avail,

but I am inclined to think that very heavy poisoning of all grass along the ditches and elsewhere frequented in numbers by the grasshoppers, if accompanied with a dusting of the cotton plants by the poison, as practiced for the cotton-leaf worm, will be the more profitable and feasible course. It is difficult to advise in the absence of direct knowledge of conditions, and I am, therefore, in response to your request, which has been seconded by the Hon. T. C. Catchings, M. C., of Vicksburg, Miss., and the requests of several other correspondents, about to send one of my assistants, Mr. James S. Hine, to make a personal investigation of the case and give such directions in regard to remedial work as, in his judgment, will be deemed most worth while after a personal investigation. Mr. Hine will proceed to Vicksburg and call on you there.

Yours, truly, L. O. Howard.

Mr. P. M. Harding,
President Delta Trust and Banking Company, Vicksburg, Miss.

As the differential locust matures as early as June 25 in the latitude of the section infested, nearly all of the grasshoppers had reached the adult condition by the time Mr. Hine arrived at Dahomy, and little if anything could be accomplished, save to carefully investigate the conditions likely to precipitate such an outbreak, and to recommend measures looking to the suppression of a similar or even more extensive occurrence of these locusts the following year.

In the fall of 1899, the writer, fearing the spread of this destructive

Fig. 1.—*Melanoplus differentialis*—natural size (after Riley).

locust into the Mississippi Valley of Louisiana, began, through the assistance of Mr. Harding, an investigation of the Mississippi situation. Specimens of eggs sent from Dahomy were placed in breeding cages and in the spring of 1900 some of the habits and the life history of the differential and other species were observed. During the winter, as the managers of Dahomy were following out the instructions given by Dr. Howard and Mr. Hine, to have the infested fields plowed and thoroughly cultivated, additional eggs were secured in sections of soil, thus augmenting our breeding-cage operations and making it possible to anticipate by cage data the development and habits of the grasshoppers in the field.

LIFE HISTORY AND HABITS OF MELANOPLUS DIFFERENTIALIS.

The following observations were made in the fall and winter of 1899 and during 1900 in breeding cages of the laboratory of the Louisiana State University, and in the fields upon and in the vicinity of Dahomy plantation, Bolivar County, Miss.

Eggs.—Eggs are deposited in masses (*oothecae*), see fig. 2, just below the surface of the ground. They are arranged irregularly in the egg sac, are small, light colored, and contrast strongly with the large, conspicuously red eggs of *Schistocerca obscura*, so often found associated with those of the differential. The period of egg-laying depends upon the time the females reach maturity; even those hatching at the same time may vary in maturing as much as twelve days or two weeks. It was found that eggs may be deposited from July 20 to October 1, and by stragglers even later. The bulk of oviposition, however, takes place between August 10 and September 15. Single females separated to determine the number of egg-pods deposited indicate in most cases that but a single batch of eggs is laid. The number of eggs in each sac ranged from 103 to 132. Mating was observed to generally take place twice at an interval of from ten to twelve days; the female ovipositing from three to five days after the second copulation.

Egg-laying areas.—Places selected for depositing eggs are more or less local, and a knowledge of them is interesting and important, as they offer most excellent means of effecting remedies.

Fig. 2.—Ootheca or egg case of *Melanoplus differentialis* (original).

The account, given above, of the basin of 300 acres which had become hard after flooding, and the spread of the grasshoppers from this region into cultivated fields suggests that any such territory is perhaps the most favorable egg-laying area; other places were found equally attractive during 1899. Ditch and bayou banks, plantation roads, the railroad right of way, upon levees, Indian mounds (common in the delta), around stumps and logs, and even in the logs, at the end of corn and cotton rows (the turn rows), in lanes, and Bermuda pastures were all found plugged with egg-pods. Just at the edges of sloughs and on the turn rows are thought by the managers to be the most common egg-laying places, but the opportunity for witnessing the females ovipositing eggs in these regions is much better than in the less-frequented waste and sodded areas, and thus we may account for the prevalence of this belief. Some females were seen depositing eggs far out in cultivated fields, but such cases were not common, and even then the harder spots near the basis of a cotton plant were selected. It was not unusual to find the egg-pods of three or even four species of grasshoppers side by side. In fact, it was due to the conspicuous colonizing of the eggs of *Schistocerca obscura* that many of the egg-laying areas of *differentialis* were discovered.

Young and adults.—Eggs remaining in the soil over winter begin hatching as early as April 15, but the majority of young emerge between May 1 and May 20. Eggs exposed upon the surface of the

ground hatch during warm spells of early spring, but those normally placed seldom hatch until continuous warm weather prevails. Those in the upper portion of the pods or egg sacs hatch first, sometimes many days in advance of those in the lower part; the species is thus protected from complete annihilation should an unexpected severe cold spell intervene between the first and second hatching.

The average life cycle of the differential locust as determined in the breeding cages is as follows:

Grasshoppers emerging from eggs on April 20, 1900, molted five times before reaching the full-grown or adult condition. The first molt took place May 7, the second May 22, the third June 2, the fourth June 13, and the last June 27. The first mating was observed July 19, the second July 28; the females deposited eggs August 3, and were dead by August 17. The entire period, minus the time required for incubation, was one hundred and nineteen days. The young on first emerging from the eggs are sordid white and after an airing of an hour or two are darker, assuming a color not unlike the dark gray alluvial soil over which they feed. There are changes of color as the earlier transformations (stages) are assumed, but until the close of the third stage these changes are not readily perceptible in the field to the naked eye. At the close of stage four the greenish-yellow color becomes prominent on many forms, and in stage five the greenish-yellow and yellow ground colors predominate. The vigorous feeding and rapid growth of the young in stages four and five, and the prominence of the wing pads in stage five, cause the grasshoppers in these conditions to appear almost as conspicuous as adults.

The habits of the young are interesting, and a knowledge of some of them may be helpful in developing remedies. After hatching they remain for several hours in close proximity to the egg-pod from which they emerged. With this period of faint-heartedness over they may venture out for a few yards each day into the grass, weeds, or crop neighboring the egg area. Upon being disturbed they invariably make the effort to hop in the direction of their so-called nest. Nymphs emerging from eggs upon a ditch bank, if forced into the water will seldom make the effort to reach the other side but will turn in the water and swim back to the bank from which they were driven. As development takes place the extent of their peregrinations into the crop is easily traced by the shot-hole appearance of the leaves upon which they feed. The tender leaves of cocklebur are always preferred by the grasshoppers in the early stages. Young Bermuda grass is also a favorite food, and succulent grasses of all kinds are freely eaten. In the third, fourth, and fifth stages, as grass, weeds, and even young shrubs disappear along the ditch banks and bayous, the crops of corn and cotton adjacent begin to

show signs of vigorous attack, and the march of destruction commences. The rather rare occurrence of more grasshoppers, even in the adult condition, upon and near the ditch banks seems to be explained in the commingled instinct of the young to hunt the retirement and seclusion of the nesting or egg-laying areas, and of the adult to seek, and survey beforehand, suitable places for oviposition. A few hours before molting the grasshoppers tend to congregate and become sluggish. Ecdysis (molting) varies as to time, and slightly as to manner, with different stages. In the early stadia less time is required, and the operation takes place upon the ground or upon low bunches of grass and weeds. Every effort of the grasshoppers at this time seems to be to avoid conspicuity, and in doing so spare themselves, in a manner, enmity of parasites. After molting of the first, second, and third stages it is not long before the young grasshoppers are sufficiently hardened to again begin feeding, but often the molt of the fourth and fifth stages, particularly the last molt, some time is required to extend the wings and dry and harden the body before feeding is resumed. The last molt usually occurs upon the upper and well-exposed leaves of corn and other plants upon which they may be feeding, though it is not uncommon for the grasshoppers to drop to the ground during the maneuvers of the process. The reason for the selection of the more exposed places for the last molt is obvious. The bodies are large, and rapid drying protects them from fungous diseases which lurk in the more shaded and moist sections during the months of June and July.

The last prominent habit to which we call attention is that of the fully grown grasshoppers to seek the shade offered by the growing plants during the hottest part of the day. Upon Dahomy plantation they appeared in such numbers a little before sunset as to change the entire coloring of the fields. Instead of the rich green, a disheartening glistening bronze prevailed.

MEANS USED TO DESTROY THE BROOD OF 1900.

The serious loss of 1899, and the alarming increase in the number of grasshoppers over 1898, together with the startling number of eggs in widely distributed egg areas, caused no little uneasiness as to the outlook for 1900. Preventives and remedial operations were begun early in the winter and were actively continued until it seemed that all danger of serious loss was past. These operations consisted in fall and winter cultivation, spraying the egg beds and young grasshoppers with coal oil and coal-oil emulsions, covering the ditch water with oil emulsions and driving the young into the trap thus prepared, of using improvised tarred sheets, and of different kinds of hopperdozers, and finally to disseminate among the developing grasshoppers a disease commonly known as "the South African fungus."

Cultivation.—Three methods were used to determine the efficacy of the method of destroying eggs. Conditions were produced in breeding cages as nearly as possible like those existing in the fields. Eggs were collected in the fields a few weeks after cultivation had occurred, and lastly careful observations were made in fields cultivated before planting and those that were not. While none of these methods, taken separately, would give exact experimental proof, yet when the results of all three are considered, the estimate may be regarded as approximate.

Breeding cages showed that after egg areas had been broken, as represented in fig. 3, and the eggs exposed to rain, frost, and sunshine for two months, that over 80 per cent failed to hatch. We failed to determine the influence of frost alone upon exposed eggs, but young

FIG. 3.—Grasshopper eggs exposed by cultivation (drawings from a photograph).

grasshoppers which had been hatched artifically, when subjected, March 15, 1900, to a temperature of 32° F., all died.

Of several hundred eggs collected on February 15 from fields which had been plowed in December, 1899, and the eggs kept from further exposure, only 30 per cent hatched and most of these came from egg pods which happened not to be thoroughly broken.

From field observations where favorable contrast could be made in egg areas cultivated and those left undisturbed the evidence in favor of cultivating is, to say the least, very conclusive. Mr. G. G. James, of Mound Landing, Miss., states, in a letter dated March 14, 1900: "While dragging a plow along a wagon road on March 12, the point dug up a few clusters of grasshopper eggs, and after finding these I had the entire road plowed up, and to my astonishment I found quantities of eggs its entire length. In a certain part, a space of about 20

feet long and 6 feet wide, there was almost a solid mat of nests." We were informed by Mr. James early in May that upon this roadbed, which had been thoroughly cultivated even as late as March 12, few of the eggs hatched, and this single experience convinced him of the value of winter cultivation. In the Delta, as far south as the State of Mississippi, warm, summer-like spells of weather often occur in winter, and fertile eggs exposed to such conditions invariably hatch, with the result that the young perish during subsequent winter weather, while eggs in pods just below the surface of the ground do not hatch until the latter part of April or early in May. It is therefore evident that the practice of fall, and even spring, cultivation is one of the most available means of destroying grasshopper eggs.

Unfortunately, upon plantations of many thousand acres, and especially upon those where a number of waste tracts occur, it is impossible to find all of the egg areas and to effect the remedy of winter cultivation.

The use of kerosene upon egg-beds at the time of hatching.—One or two seasons' experience with grasshoppers greatly quickens the powers of observation, and egg-beds not discovered in the fall and winter may be detected the first week in May by the presence of the young grasshoppers. Upon Dahomy spray pumps were kept actively at work upon egg areas, spraying each with 12 per cent coal-oil emulsion at least once a day. It often happened that as many young grasshoppers were in evidence the day following each application, but careful observation soon revealed the fact that only those hatching after the emulsion had been applied survived, and those were killed by the next spraying. While the emulsion spray was found expensive when compared with that of cultivation, yet in the face of such conditions as prevailed in the Mississippi Delta its effectiveness many times outweighed the expense. Applications of coal tar were not made to the egg-beds, but there is every reason to believe that this substance would also have proven useful. The use of coal tar in the hopperdozer and upon the drag sheets certainly warrant a trial of it upon egg areas.

Spraying ditches.—The experience in spraying ditch banks soon developed the cheaper and perhaps more effective method of destroying young grasshoppers, that of damming water in the ditches and covering the surface with coal oil or coal-oil emulsion. Before and after rains the ditches were dammed and the water covered with a 12 per cent coal-oil emulsion. The young grasshoppers were then driven into the ditches, with the result that very few, if any, escaped. In this way a single application of oil would last several days, as many millions may easily float upon the water of a ditch not more than 2 feet wide. Unless the grasshoppers are scattered too far from the ditch banks no difficulty is experienced in getting them to move in the

direction of the oiled water on account of the "homing" instinct above mentioned. Young grasshoppers will not drive more than from 10 to 20 feet before taking what is commonly termed by the plantation managers "the sulks," when they cease hopping and show an aggravating indifference to the brush of the switches used in driving them. The necessity of early learning the location of the egg-beds and the time of hatching is obvious if the ditch method be practiced.

Upon river plantations many open ditches are indispensable, and when rains are sufficient to keep them filled or partly filled with water they serve a most excellent purpose in the destruction of young grasshoppers. During the grasshopper campaign of 1900 over 225 barrels of coal oil were used upon Dahomy and not a little of this quantity was placed upon the water of the ditches of the plantation in the form of emulsions. At the height of the season as many as 50 miles of ditches were oiled, and the number of young grasshoppers killed may be roughly estimated when we state that the surface of the water for this distance was completely covered. After the water evaporated the stench from decaying grasshoppers was very perceptible, and had it not been for the satisfaction of knowing that millions had been slain the stench, no doubt, would have been objectionable.

Mr. Robert Glenk, a member of the experiment station staff of Louisiana, spent two weeks in the field in charge of the grasshopper work, and in his report to Mr. Harding, dated May 31, 1900, says:

> Sunday afternoon brought up a heavy rain and filled many of the ditches with standing water. We had oiled the surface of the water and made a combined attack upon the insects, which has resulted in their wholesale destruction. We are using gangs of men and are making a systematic drive to the ditches.

One hitch occurred in the use of the emulsion. In driving the tank wagon over rough ground the emulsion became so thoroughly churned that the oil separated and floated to the top. This condition, however, was soon revealed by the effectiveness of the spray. The use of the pump, which mechanically mixes the oil and water, should obviate this difficulty.

Tarred sheets and hopperdozers.—The operation of the ordinary hopperdozer may be considered an easy matter in meadows, pastures, and over crops planted upon the level, but one has to experience once the trouble of working a hopperdozer in alluvial sections where the high ridging of the land prevails to realize that the ordinary use of the hopperdozer is impracticable. To construct one of these implements suitable to alluvial conditions will require further experience and trial. During the efforts with the hopperdozer Mr. C. D. Patterson, general manager of Dahomy, improvised a tarred sheet similar to

that illustrated in fig. 4. It consists of six attached strips of osnaburg 6 feet long, with light poles attached to the ends. The sheet was kept moist with coal tar and was dragged by a mule along all the ditch banks and even down in the ditches where this was possible. Several of these sheets were made and kept actively at work while the grasshoppers were young, and great numbers of the insects were thus collected. While these sheets possess the merit of not breaking the young corn and cotton and of catching myriads of the grasshoppers, it is to be regretted that they soon wore out when dragged over cultivated areas.

The hopperdozer, which was finally constructed and which possessed

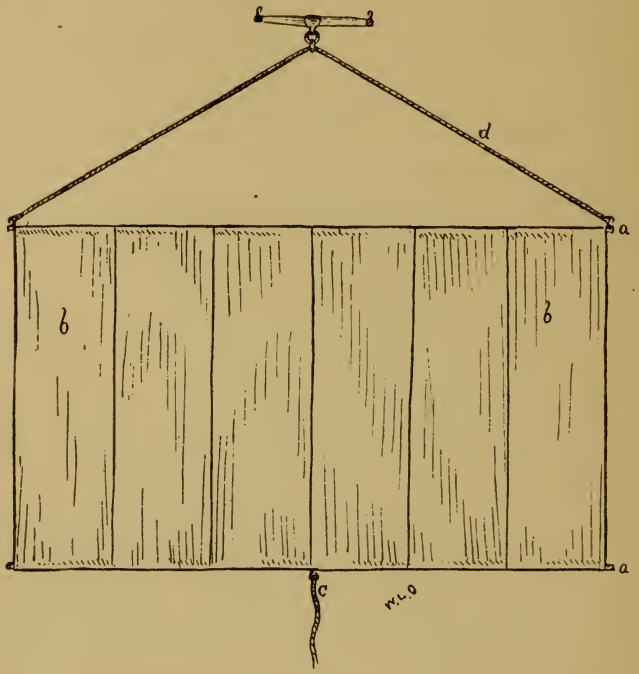

FIG. 4.—Patterson tarred sheet: *a*, strip of wood supporting sheet; *b*, strip of osnaburg; *c*, guide rope; *d*, hitch rope (original).

much merit when run diagonally over the rows of cotton and corn, consisted of three runners 3 inches high and 2 feet long, a pan of corrugated or sheet iron, and a back of osnaburg. (See fig. 5.)

Two more contrivances for catching young grasshoppers are to be recommended. These are of value during dry weather when it is impossible to hold the rain water in the ditches, or to fill them from the river or neighboring bayous by irrigating pumps. One is a hopperdozer sufficiently narrow to run in plantation ditches and light enough to be handled by a man upon the sloping ditch banks. They will prove serviceable, too, upon limited egg areas when the young are emerging. The other is a tarred strip of osnaburg just as long as

can be conveniently handled in the bottoms of dry ditches. A strip 30 or 40 feet long will suffice. After this is stretched in the bottom of the ditch the grasshoppers are driven from the sheet just as they are driven into oiled ditches, and as soon as the distance of the length of the strip is cleared the canvas is hauled forward and the drive again made. This continued, the ditch banks may be as effectively cleaned in dry weather as when the ditches are filled with water.

The bran-arsenic mash.—The experience of Mr. Harding in 1899 (see his letter July, 1899) rather discouraged an extended effort with

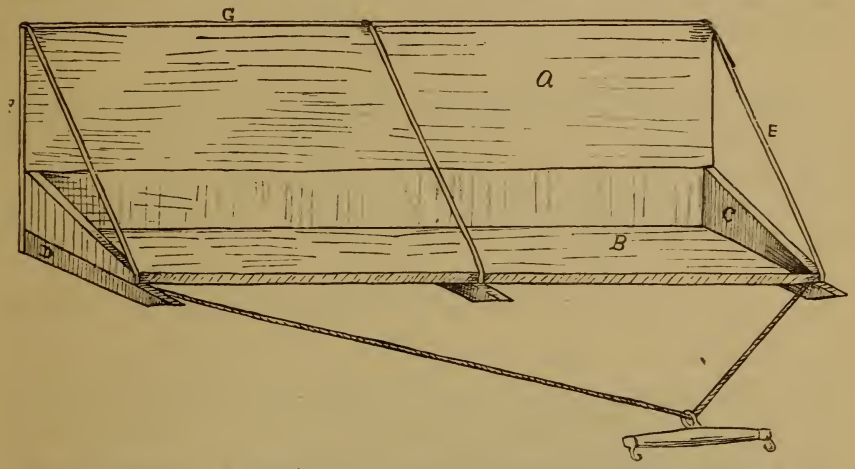

FIG. 5.—Hopperdozer: *A*, osnaburg back; *B*, pan; *C*, wooden ends of pan; *D*, runners; *E*, *F*, *G*, supports (original).

this bait. Mr. Glenk, however, ventured a number of trials with the mash and writes of it as follows:

I placed the arsenic mash in many places with moderate success. Found a few dead grasshoppers on the leaves and around the mash. The rain, however, interrupted my experiments.

The mash can not be relied upon in severe outbreaks, such as occurred in the delta, but may be used in limited attacks where the area affected would not warrant the more aggressive methods.

The South African fungus.—On May 24 the following letter was received from Dr. L. O. Howard, inclosing Mr. Edington's directions for the culture and spread of the fungus, which are also herein given:

MAY 22, 1900.

DEAR PROFESSOR MORGAN: In response to your letter I am sending you six of the tubes of the South African locust fungus, together with a duplicate of a letter which I have just sent to Mr. Harding, at Benoit. I think it will be advisable for you to grow the fungus in the laboratory. Mr. Edington, director of the Bacteriological Institute, writes me that it is best grown on saccharinated agar-agar, which is very faintly acid in reaction. I hope you will report results. The South African circular of instructions is inclosed.

Yours, very truly,

L. O. HOWARD.

Prof. H. A. MORGAN, *Baton Rouge, La.*

[Inclosure.]

LOCUST DISEASE FUNGUS.

Small tubes containing this fungus are prepared at this institute and supplied to all applicants, who may also obtain them by application through the civil commissioner of their division.

The methods mentioned below should be followed, and the result carefully watched and reported to me.

Highly satisfactory results have hitherto been obtained, and it is particularly requested that all persons using the fungus will report the result of their experiments to this institute.

During dry weather it is difficult to get the disease to spread, and hence it is advisable to use it in moist or wet weather, and to make the infection of the swarms just before sunset.

DIRECTIONS FOR PREPARING THE FUNGUS PREVIOUS TO USE.

Open a tube and take out the contents entire; add to it two teaspoonfuls of sugar, and rub the whole together with a spoon or flat knife, so as to break up the material and mix it thoroughly. Then dissolve this in three-fourths of a tumblerful of water, which has previously been boiled and allowed to cool. Float in this a few pieces of cork, which have been previously steeped in boiling water and cooled.

Now cover the tumbler with a piece of paper, and let it stand during the day in a warm corner of the house or until the fungus is seen to be growing around the pieces of cork.

METHOD OF DISTRIBUTION.

(1) Catch some locusts, and, after dipping them into the fungus, let them go into the swarm again.

(2) Smear patches of damp ground, where the locusts alight to feed, with the fungus.

(3) Confine some locusts in a box which contains some favorite food moistened with the fungus, and, after the food has been eaten, return the locusts to the swarm.

(4) Collect a large number of locusts which have died from the fungus. Dig a hole in the ground about 18 inches deep and 1 foot wide.

Strew some locusts over the bottom, then sprinkle some water over them. Repeat with locusts and again sprinkle until the hole is full. Do not press the locusts into the hole, but leave them lightly packed. Then cover over with a piece of tin or board and keep the hole thus carefully covered for four or five days. If very warm weather, four days will be sufficient, but if colder a longer time will be required.

At the end of this time remove the locusts and spread them out in the sun for an hour or two, or until thoroughly dry. Now grind them into a meal.

Of this meal, which may be kept dry for a long time until wanted, take two tablespoonfuls and add it to a large tumblerful of water, into which some sugar has been placed. Leave this in a warm place for twelve to forty-eight hours, and then treat live locusts by dipping, etc., just as one does in using the fungus when supplied in tubes.

METHOD OF APPLICATION FOR VOETGANGERS.

Take about 1 pound of white bread; dry it, and then grate it down into coarse powder. Put a cupful into a bowl and add enough water to make a watery paste. Add to this the contents of one tube of fungus, and keep it in a warm place until the fungus is seen to be growing over it. Now place small portions where the voetgangers are appearing, and take care to see that where not eaten up the small portions are kept moist from day to day until they have been eaten.

ALEXANDER EDINGTON, M. B.,
Director Bacteriological Institute, Grahamstown.

FEBRUARY 19, 1899.

These tubes, together with six more sent directly to Mr. Harding at Benoit, Miss., were with instructions turned over to Mr. Glenk, and on May 31, 1900, Mr. Glenk made the following report to Mr. Harding:

The South African fungus came duly to hand. I immediately began its propagation in the manner directed, and steeped the grasshoppers and their favorite food

(cocklebur) in the liquid and fed a large number of hoppers with it. Two infection boxes were started, with dampened soil covering the floor and cheese cloth the tops, and the insects were placed in contact with the spores of the fungus. The infected grasshoppers were liberated in various badly infested spots, and the results which should be noticed in a few weeks are looked forward to with much interest.

In a letter to the writer dated June 5, 1900, Mr. Glenk states:

I have had better success with the fungus than when you were here. I made an incubator out of some boxes and used my lamp for keeping an even temperature. The fungus grows well in a warm, moist atmosphere. I dissolved the nutrient agar-agar in two of the tubes, in hot water, mixed with it the sugar solution, added the fungus film, stirred well to distribute the spores, and poured the solution upon the leaves and moist earth. Dead grasshoppers were found in both of my infection boxes in a few days. I used up all the tubes received from Dr. Howard and made up enough liquid for all the managers. We put out a dilute solution of the fungus over several badly infested areas and spread it upon the grasshoppers, and the leaves of corn and cotton in many parts of Dahomy.

The month of June was very propitious for the spread of disease among grasshoppers. Rains began the latter part of May, and during June 9.29 inches fell at Greenville, Miss., 40 miles south of Dahomy, the nearest point where meteorological records are kept.

On July 18, 1900, the writer received the following from Mr. C. D. Patterson, general manager of Dahomy:

By request of Mr. P. M. Harding I am sending you by mail to-day some dead grasshoppers, which we find attached to weeds on ditches and bayou banks. We also find a few on cotton. Mr. Ike Edwards (manager of Matthews place) tells me that he has found as many as six dead grasshoppers upon one stalk of cotton. The dead grasshoppers I am sending you were gotten on Glass place.

Early in August a visit was made to Dahomy, with a view of making some observations upon the spread of this fungus, and it was found that over the areas where the liquid infection was spread by Mr. Glenk diseased hoppers were abundant. As many as a dozen dead grasshoppers could be found upon a single plant, and some upon nearly every weed on ditch banks where grasshoppers were numerous. From the centers of infection great areas had become inoculated, spreading even beyond the plantations first infected. While a local fungus (*Empusa grylli*) was in evidence throughout the delta, the general spread of the imported fungus upon Dahomy indicates a thorough infection of this property with the South African fungus. The spread of the disease is similar to that reported from Colorado, where, Dr. Howard informs me, the disease has also done effective work.

Associated with the differential locust in the same tracts of land were numbers of a much larger locust, the *Schistocerca obscura*, as well as many of the local species of grasshoppers found throughout the delta any season. Of all the specimens sent to the laboratory and of all those observed in the fields none were found to succumb to the fungus but the differential.

Miscellaneous experiments.—The habit of the differential to remain along sloughs, ditch banks, etc., suggested the scattering of lime, acid phosphate, kainit, and other substances to check the march of the grasshoppers out into the crops; but, as none of these materials proved of any value, a continuation of this line of work was early abandoned.

We found it advisable not to destroy cockleburs growing in the vicinity of the egg areas, as this plant is the favorite food of young grasshoppers and serves to congregate them, which not only renders more available effective remedies, but also preserves the stand of corn and cotton in these localities. Where it is possible, we also recommend delaying the cutting out of the crops to a stand until the young hoppers have been destroyed by some or all of the remedies stated above.

NATURAL ENEMIES.

Aside from the very timely rainfall during the latter part of May and in June, there were many predatory and parasitic enemies found common to the differential locust in the Mississippi Delta.

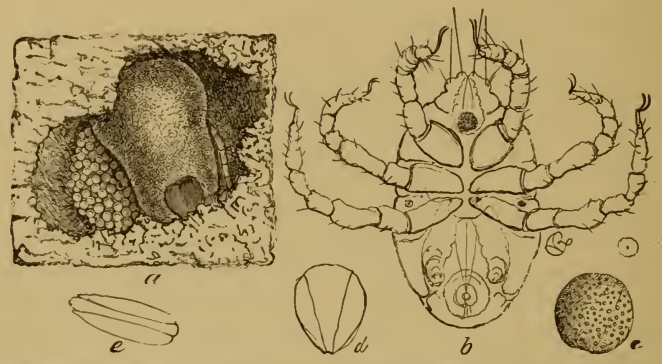

FIG. 6.—*Trombidium locustarum*: *a*, female with her batch of eggs (from Emerton); *b*, newly hatched larva—natural size indicated by the dot within the circle; *c*, egg; *d*, *e*, vacated eggshells (from Riley).

Upon the eggs.—Three predatory and two parasitic forms were found feeding to a greater or less extent upon the eggs.

The locust mite, *Trombidium locustarum* (see figs. 6 and 7), which occurs throughout the United States and Canada was in evidence in the Mississippi Delta. The full-grown mites, as well as bunches of the small red-colored eggs, were commonly seen during the cultivation of the land in April and May. While most abundant in the vicinity of the egg-beds, it was not uncommon to find them anywhere over the entire plantation. Many were placed in breeding cages where quantities of eggs of *differentialis* and of other species were kept, but we were disappointed somewhat in not finding them more ravenous feeders upon grasshopper eggs. From the statements of other observ-

ers of their beneficial attack upon eggs it may be that our cage conditions were not suitable for aggressive work of this mite. The numbers to be found were very assuring and this mite must be recognized as an important enemy to grasshoppers.

The larvæ of a species of Carabid beetle, which we were unable to

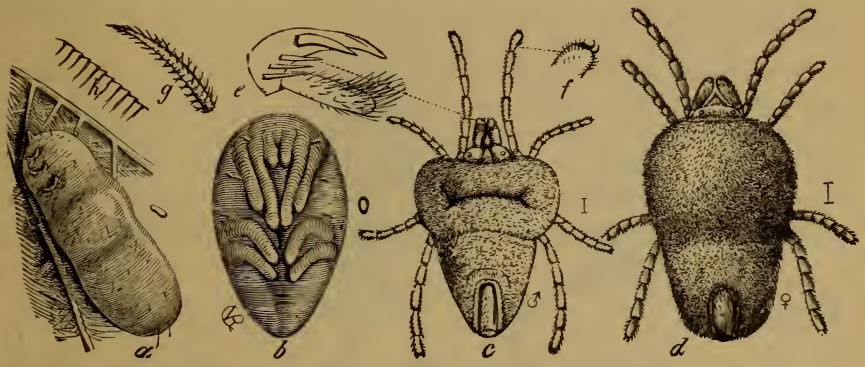

FIG. 7.—*Trombidium locustarum*: *a*, mature larva when about to leave the wing of a locust; *b*, pupa; *c*, male adult when just from the pupa; *d*, female—the natural size indicated to the right; *e*, palpal claw and thumb; *f*, pedal claws; *g*, one of the barbed hairs; *h*, the striations on the larval skin (from Riley).

rear to the adult condition, were also found to be an energetic feeder upon eggs. With their large mandibles they were observed breaking the egg sacs and devouring the contents.

During April, May, and June the ash and black colored blister beetle (*Macrobasis unicolor*) (see fig. 8) showed by its numbers and the manner of the attack of the young to be an important enemy of grasshopper eggs. In sweeping they were a common capture, and in following the plows and cultivators the pseudo pupæ (coarctate) were seen in great numbers. The young of the first and second stages were also found among the egg-pods.

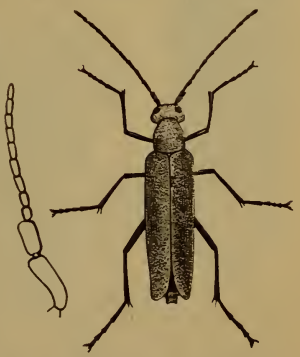

FIG. 8.—*Macrobasis unicolor:* Female beetle at right, twice natural size; male antenna at left, greatly enlarged (from Chittenden).

Of the true parasitic forms two species were bred, *Scelio hyalinipennis* Ashm. and *Scelio œdipodæ* Ashm. While the former species appeared earlier than the latter, both continued to emerge as adults irregularly from May 1 until the latter part of June. They were found to come in the majority of cases from the eggs of the lower end of the pod, and in a few instances this was found the case even where grasshoppers were coming from the upper ends. As a rule not all of the eggs of the pods are parasitized, and the inference is that the habit of the parasites to attack the deeper placed eggs is to so retard the development of the offspring as to guarantee food for the broods that

follow. As the eggs of the differential are not deposited before August 15, the appearance of the parasites long after the young grasshoppers emerge suggests that, were they to appear earlier, the species would perish for lack of food. Those reaching the adult as early as June find food in the eggs of species of grasshoppers which deposit their eggs in the spring as *Schistocerca americana*, or in those of double brooded species, as *Chortophaga viridifasciata*.

Parasites of nymphs and adults.—As the fight against the grasshoppers progressed it was thought of interest to determine, as far as possible, all of the natural agencies at work, that with a fuller knowledge of these we might better know how to direct the expensive and time-consuming artificial measures, or knowing more accurately nature's rigid methods of establishing equilibration among the beings

FIG. 9.—*Sarcophaga sarraceniæ:* Larva at right; adult in center; puparium at left—enlarged (from Howard).

in her charge we might assist and encourage her with less expense and more profit than carry out our own.

From time to time hundreds of grasshoppers were collected and confined to cages where each day quantities of fresh food were given them. As the later stages of the grasshoppers were reached maggots were noticed emerging from the conjunctivæ (sutures) of the abdomino-thorax and head. None, however, appeared until after the specimens had died, either from the conditions of confinement or from the attack of the parasites. As the collections were made after the "South African fungus" had been spread, many of the specimens were attacked by the parasitic flies and the fungus as well. Just to what extent the attack of the fungus encouraged the attack of the flies we were unable to determine.

Of the parasites bred most of them are peculiarly orthopterous enemies belonging to the genus Sarcophaga. Of the flies reared there were six Sarcophagids, two Tachinids, and one Muscid. The identifications were made by Mr. Coquillett and are as follows: *Sarcophaga sarraceneæ* Riley (fig. 9), *S. assidua* Walker (fig. 10). *S.* sp. near *incerta*

FIG. 10.—*Sarcophaga assidua:* Puparium at left; adult in middle, with enlarged antenna; larva with enlarged parts at right—enlarged (from Howard).

Walker, *S.* sp. near *cimbicis* Towns., *S. hunteri* Hough, *Helicobia helicis* Towns., *Euphorocera claripennis* Macq. (fig. 11), *Acemyia dentata* Coq., *Lucilia cæsar* Linn. (fig. 12).

Of the above species *Helicobia helicis* Towns. was the commonest fly bred. By isolating specimens of the differential locust, in order to derive information relative to its life history, a part of the life history of *Helicobia helicis* was incidentally reached. May 26, 1900, a specimen of grasshopper of the third stage was placed in cage. The last three molts were successfully accomplished and a few days after this female—for the specimen proved to be a female—had reached maturity a male was given her. Mating took place twice and a single pod of 132 eggs was deposited. August 16, 1900, the female died and was placed in a separate tube cage for further examination. During the period between August 28 and September 1 six maggots of *Helicobia helicis* emerged from the body of this grasshopper. Within forty-eight hours all had entered the puparia, and on September 17 the last of the flies appeared. From the above

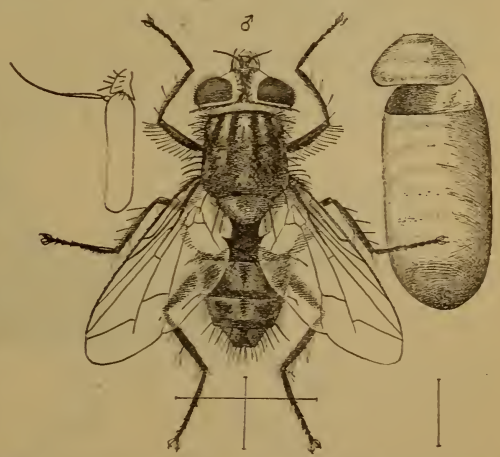

FIG. 11.—*Euphorocera claripennis:* Adult with enlarged antenna and with empty puparium at right—enlarged (from Howard).

observation it is evident that the eggs (or maggots) of the parasite were placed upon the host (this grasshopper) previous to the third molt, and that the larval life of the parasite is at least as long as from May 26 to August 28, or a period of ninety-five days. It is astonishing that all of the natural functions of grasshoppers went on during this remarkable period of parasitic attack.

Just to what extent the parasitic flies lessened the number of grasshoppers it is difficult to say owing to the prevalence of fungous diseases. Numbers of dying specimens were examined, and the viscera of those specimens infested with the fungus was much more disintegrated than those attacked by maggots, yet, as many of the grasshoppers were common hosts of disease and maggots, it was impossible to arrive at any very definite conclusion. Little information could be gotten from examination of the dead grasshoppers in the field as numerous ants soon deprived the hoppers of viscera or parts of viscera left by the maggots.

FIG. 12.—*Lucilia cæsar*—enlarged (from Howard).

From the puparia of *Helicobia helicis* two secondary parasites were reared. One of these, *Aphærreta pallipes* Say, was bred August 3, the other, *Perilampus cyaneus* Brullé.

The young of the locust mite was found to do effective work as parasites upon the wing pads and wings of grasshoppers. Upon the majority of those collected in the fifth and last stages young mites were common guests.

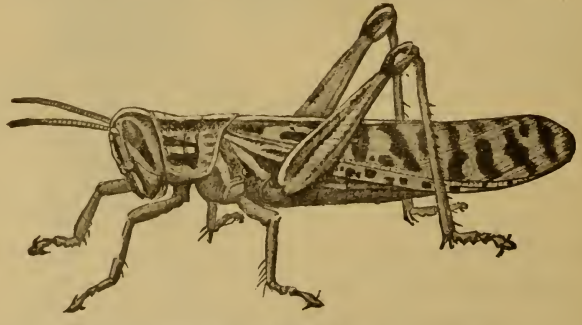

FIG. 13.—*Schistocerca americana:* Adult (from Howard).

Blackbirds and turkeys were observed to feed upon grasshoppers in all stages, and upon some plantations turkeys were purchased and liberated in infested fields. The exact information is not at hand as to the real merit of turkeys, but a common belief prevails that they may be made to serve a very practical purpose in grasshopper outbreaks.

These belong to the families Acrididæ and Locustidæ. *Schistocerca americana* and *Schistocerca obscura* were the most common of the former family.

Schistocerca americana or bird grasshopper (see fig. 13).

This species is single brooded, deposits eggs in the spring, and hibernates in the adult condition. Specimens collected early in May deposited eggs May 15. In the field the egg-laying places are usually

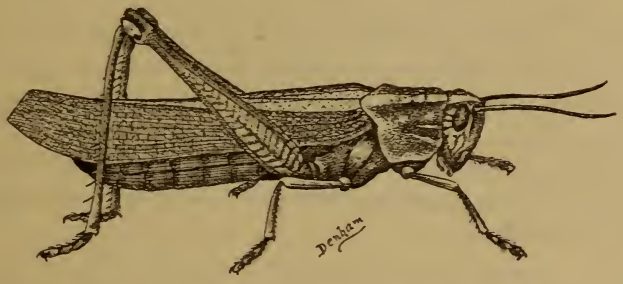

FIG. 14.—The full-grown *Schistocerca obscura* (original).

Bermuda-covered spots and waste areas. Eggs hatch about June 15, and the young molt six times (June 23, June 29, July 5, July 11, July 20, and August 5) before reaching the adult condition. In the delta the grasshopper attracts considerable attention owing to its size and bird-like appearance when in flight, yet it has never appeared in threatening numbers. Mr. C. D. Patterson, commenting upon the habits of this species, stated that during the clearing up of the waste lands in winter, as the flies ascended the tall trees, these large grasshoppers would fly out from the upper limbs in great numbers. Just how they found shelter among the higher branches of trees is unknown. We found it difficult to carry the bird grasshopper through the winter in captivity, and only succeeded in keeping specimens alive until February 2. In the fields, however, a few specimens have been collected from January until the last of May. No parasites were bred from those captured and no special remedial efforts were directed against this species. The egg areas were found, however, and cultivation and the use of coal oil will no doubt prove effective.

FIG. 15.—The fifth stage of *Schistocerca obscura* (original).

Schistocerca obscura.—(See figs. 14 and 15.) This species in size and shape is not unlike the bird grasshopper. Attention was first called to it in the egg condition. The large brick-red colored eggs are to be found associated with those of *Melanoplus differentialis*. A few

egg sacs were isolated and during the latter part of May the young grasshoppers made their appearance. In the first and second stages they are pea green, but in the third stage changes in the ground color occur. Some remain green, while equally as many become brown. The body and appendicular markings of the two color varieties remain the same. This locust hibernates in the egg condition, though the eggs are deposited much later than are those of *differentialis*. Adults placed in the breeding cages on October 15 deposited eggs November 2. Five molts occur before maturity is reached. Young emerging from the eggs on May 28, 1900, molted June 10, June 19, June 29, July 8, and July 28. Adults in confinement are shy and soon die in captivity. In destructiveness to crops of the Mississippi Delta this species stands next to *differentialis*. It readily attracts attention by its size, color, and vigorous flight. Notwithstanding its prevalence, not a single specimen was found attacked by parasitic flies or by the South African fungus. *Scelio hyalinipennis* Ashm. was bred from the eggs, as was *Scelio adipoda* Ashm.

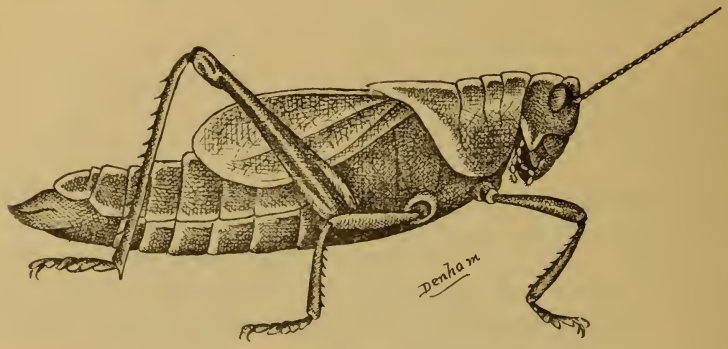

FIG. 16.—The large black grasshopper *Dictyophorus reticulatus* (original).

The egg beds of this species being similar in position to those of the *Melanoplus differentialis* the remedial measures recommended for *differentialis* will prove effectual for this.

Dictyophorus reticulatus.—(See fig. 16.) This large black species is a short-winged form, is only locally distributed and may occur only in spots, even upon a small plantation. It is a voracious feeder, preferring the coarser grasses and sedges of swamp areas. Its wandering into cultivated crops is only occasional, and hence this locust does not attract much attention.

The eggs are deposited in sodded areas all during the month of August (see fig. of egg pod; fig. 17).

By September 15 females are rare, not more than 10 per cent of hundreds collected at this time were females. This is just the opposite of the observations upon *differentialis*. Males usually die a few days in advance of females. Eggs of Dictyophorus hatch as early as April 20. As is usual with most Acridids five molts occur in the

process of development, the last one occurring from June 25 to July 1. The mating season begins in from fifteen to twenty days after maturity, and in as many more the oviposition season begins.

From the local distribution of this locust, as well as its large size, conspicuous coloring, and lubberly movements, no trouble is experienced in destroying it. The bran arsenic mash had been used upon this locust with good effect. Locating the eggs and exposing them by winter tillage is the most practical remedy. In very local outbreaks the net has been used to collect both nymphs and adults. A species of Sarcophagidæ has been found a common parasite of this grasshopper.

Dissosteira carolina.—The Carolina locust eggs resemble very much in size and form those of the *Schistocerca obscura* after the coloring from the latter has been removed by alcohol. (This coloring of the eggs of *obscura* resembles in its reactions the color extract from the petals of red roses.) The eggs are laid in the same areas as *differentialis* and *obscura*. The preferred food of the young we were unable to determine, and hence were unsuccessful in the effort to determine the life history of this locust. Grasshoppers of all species are difficult to rear in cages, and this one we found no exception. The young would congregate upon the window side of the cage, and would there remain until starved to death. Cockle-burs, which were readily eaten by other species, were only occasionally nibbled. This locust did not appear in destructive numbers and is given consideration only because the eggs and young are frequently confounded with those of the differential. From field observations the period of development of the Carolina locust is about equal to that of the differential, though mating and egg-laying is later.

FIG. 17.—Egg sac of *Dictyophorus reticulatus* (original).

Chortophaga viridifasciata.—This species is widely distributed through the South, and though it appears in the Mississippi Delta in unusual numbers for this species, the damage done was not appreciable. It is here considered for two reasons: First, the young appear early in the spring and have been frequently mistaken by planters for the differential. The young of the first brood appears as early as the middle and last of March. It is double brooded, and receives a second consideration because the eggs act as food for differential egg parasites which appear earlier than August 15 and September 1. The first brood matures about May 15 and the last from October 1 to 18. As hibernation is passed in the egg condition, fall and early winter cultivation will prove destructive to the eggs.

Melanoplus atlanis and *Chloëaltis viridis* were also found upon Dahomy, but not in sufficient numbers to warrant any alarm. Specimens of *atlanis* were received from the alfalfa sections of the Red River

Valley in Louisiana, and were reported by Mr. George W. Arnold, of Vanceville, La., as injuring alfalfa. No opportunity was presented for a study of its life history and habits.

FIG. 18.—Field locust (*Orchelimum agile*) (original).

Field locusts.—In August, September, and October from among the coarse ditch grasses and those of swamp and waste places come the rasping sounds and almost continuous buzz of the field locusts. Not much attention has been paid to these long-horned grasshoppers or locusts. In ordinary seasons they are not prone to wander from the ditch banks, but when the differential prevails, they are forced into the crops in search of food. In 1898 and 1899 considerable damage was done. The prevalence of a species of Orchelimum may be imagined when in certain sections of the Delta, particularly near Mound Landing, Miss., hundreds of acres of dry cotton stalks were found to contain numbers of eggs in every branch and twig (see fig. 19 showing general appearance of punctured stalks and position of exposed eggs). These eggs were also found abundant in the tassel stalks of corn in widely distributed fields.

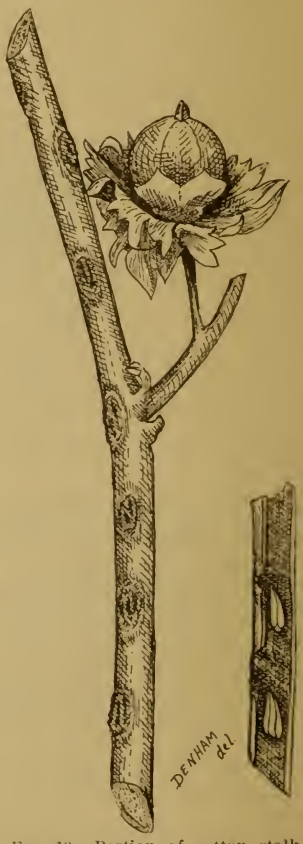

FIG. 19.—Portion of cotton stalk showing punctures and eggs of *Orchelimum agile* (original).

The eggs hatch during the latter part of May and continue until June 20. Moisture has much influence upon hastening incubation and hatching. In cages the stalks of cotton were moistened every few days, and after each dampening the young emerged more numerously. The exact number of molts was not determined. After molting the young devour the cast skin and frequently they have been found devouring one another. Maturity is reached very irregularly owing to the difference in the time of hatching and of the variations of development. The form most commonly found upon Dahomy was *Orchelimum agile* (see fig. 18). It matures from the middle of July until September 1, deposits eggs from fifteen to thirty days after reaching the adult, and winters in the egg condition. In 1899 *Orchelimum agile* was a real enemy to cotton,

but the habit of depositing eggs in cotton branches and the tassel stalks of corn suggest the burning of all egg-infested cotton and corn stalks, which has been the common practice upon some plantations.

The field locust eggs are common hosts of two hymenopterous parasites. *Eupelmus xiphidii* Ashm. MS. and *Macroteleia* sp. near *floridana* Ashm. In breeding cages the latter appeared during the month of June, while the former appeared at intervals from July 21 until October 15; the majority, however, emerged between August 25 and September 18, and all were females. It is interesting to note that the parasite delays development and reaches the adult stage at a time when locust eggs are fresh and more or less abundant.

From adult locusts a number of Sarcophagid flies, *Helicobia helicis* Town. were bred. The maggots appeared on September 15, pupated September 17, and matured September 24.

THE RELATION OF CREVASSES AND RAINFALL TO THE APPEARANCE AND DISAPPEARANCE OF GRASSHOPPERS.

Planters operating behind the levees of the Mississippi River have, from experience, begun to expect insect outbreaks of one kind or another after overflows. In many sections the Southern grass or army worm (*Laphygma frugiperda*) makes its appearance in damaging numbers, while in other places grasshoppers and the army worm may both become destructive. It has been frequently observed that previous to crevasses predaceous beetles of many kinds are abundant on alluvial lands. They feed upon the army worm and easily keep them in check. During crevasses the beetles are either destroyed or are carried to other places by the flow and rush of the crevasse water. As soon as the water recedes and the land is put in cultivation the army-worm moths from neighboring sections fly in, and as this species is a rapid breeder, the crops of the overflowed area are soon infested with armies of caterpillars. It is usually a month or more before the predaceous beetles can migrate in numbers sufficient to check and overcome the march of the caterpillars.

In the case of the grasshopper the conditions are somewhat different. A part of the overflowed land may be thrown out of cultivation a season or more, and thus nesting places are provided. Should heavy rains prevail during May and June of the season immediately following the crevasse, nothing is heard of the ravages of grasshoppers; but should dry summers follow, the conditions for grasshopper propagation and development are much more favorable, and complaints are usually common. The relation of predaceous beetles to grasshoppers is not so intimate as in the case of the beetles and the army worms, though it must not be wholly disregarded, nor are the rains so destructive to the army worms as to grasshoppers.

The above statement of conditions is given in order to emphasize the importance of a study of the conditions of insect outbreaks. Were we better acquainted with accurate environments preventive measures would invariably take the place of the more expensive remedial ones.

Capt. Charles L. Potter, Corps of Engineers, Memphis, Tenn., has kindly furnished the following list of the breaks occuring in the Mississippi River (between Rolling Fork and Coahoma, the grasshopper infested territory) since 1887:

Name of crevasse.	Distance by river from Cairo.	Date.	Remarks.
	Miles.		
Offutts	444	Mar. 18, 1890	
Skipwith	530	Mar. 26, 1890	
Mound Landing	435	Mar. 28, 1890	
Huntington	438	Mar. 28, 1890	
Austim	288	Apr. 3, 1890	About 30 miles above Coahoma.
Catfish Point	432	Apr. 4, 1890	
Robertsonville	354	Mar. 11, 1891	
Stella	503	Apr. 3, 1891	
Deerfield	492	Mar. 28, 1897	
Sledge	380	Mar. 30, 1897	
Stop Landing	434	Mar. 30, 1897	
Flower Lake	300	Apr. 4, 1897	About 20 miles above Coahoma.
Shipland	548	Apr. 21, 1897	Latitude 8′=about 10 miles south of Rolling Fork.

There were no crevasses in the Mississippi levees from 1887 to 1890.

A small crevasse occurred at Greenville in 1891 that was closed before the discharge was appreciable.

All the breaks except those at Flower Lake, Austim, and Shipland are located between Coahoma and Rolling Fork.

Grasshopper outbreaks occurred in 1891 and 1892, and again in 1898, 1899, and 1900. It is a significant fact that the rainfall of May and June, 1893, and of the same months in 1900 had a decided effect in suppressing the injurious numbers of grasshoppers, and conversely, the dry summers immediately following the crevasses encouraged greatly their development.

The following table of rainfall for Greenville, Miss., the nearest meteorological station, furnished by Mr. W. S. Belden, acting station director, Vicksburg, Miss., supports the above conclusions.

Rainfall at Greenville, Miss., 1888–1900.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1888	6.11	2.41	9.88	1.65	4.54	3.95	2.28	10.39	2.69	1.61	3.89	3.89	53.29
1889	4.89	2.71	1.85	2.60	4.03	7.09	4.50	1.86	4.05	0.40	5.92	1.05	40.95
1890	4.98	6.30	6.63	11.01	4.67	2.31	2.23	2.09	4.94	2.79	1.48	3.94	53.37
1891	3.79	8.38	4.43	2.24	3.42	3.02	12.32	2.44	1.54	0.86	5.40	3.40	51.24
1892	5.59	3.60	3.91	9.74	2.93	2.54	9.25	3.50	6.96	0.80	2.44	6.54	57.80
1893	4.03	5.27	2.70	5.69	7.39	6.59	2.33	2.87	2.67	0.34	6.34	1.87	48.69
1894	7.37	3.19	9.48	4.48	0.61	0.30	5.09	.....	1.17	1.53	0.35	4.25	37.81
1895	6.32	5.24	.....	1.71	1.32	11.50	4.30	7.23	0.37	1.20	3.78	3.58	45.55
1896	3.29	5.24	7.98	2.48	1.09	0.71	0.85	1.84	0.74	3.20	4.73	0.17	32.32
1897	4.31	4.05	11.48	1.96	2.19	1.05	3.85	2.24	T.	2.20	2.96	8.37	44.66
1898	8.19	2.89	2.94	3.83	3.15	2.54	1.57	7.51	6.12	5.85	4.60	1.51	50.70
1899	5.30	4.57	5.21	2.19	4.67	1.51	2.10	0.87	1.18	1.15	0.94	4.23	33.92
1900	1.94	5.44	5.64	7.11	4.02	9.29	6.11	0.93	2.58	5.03	.....	.....	[1]42.98

[1] For 10 months.

The habits of young grasshoppers to seek the soil crevices during a rain results in the burial of millions beyond the possibility of a resurrection. This, with the development and propagation of fungous diseases among the nymphs, are the most potent natural agencies which destroy grasshoppers during wet summers.

The fact that the differential locust will deposit eggs in logs has given some support to the idea that crevasse water introduces the grasshoppers. There are sections of the delta, however, which are almost annually overflowed by the high water of the Mississippi and its bayous and which would be common infesting grounds were this the case, but these do not seem to suffer except when dry summers prevail.

SOME INSECTICIDE EXPERIMENTS.

By C. L. Marlatt.

A series of experiments with certain insecticide substances was made in the spring and early summer of 1900 and are herewith recorded. The experiments were especially designed to test the effect of various substances which might be used against the San Jose scale, both as to their effect on trees and efficiency as destroyers of the scale. They included work with (1) crude petroleum; (2) refined kerosene; (3) lime, sulphur, and salt wash; (4) hot water; (5) Bordeaux wash and kerosene emulsion; and (6) a kerosene and lime emulsion. The experiments with the latter two substances were made at the suggestion and with mixtures furnished by Professor Galloway. An experiment was also made, at the suggestion of Dr. L. O. Howard, with a heavy lime wash or whitewash. For the washes containing lime the period immediately following the applications was unusually favorable, little rain falling for upwards of two or three weeks. In the use of crude petroleum and kerosene nothing especially new is to be noted except the fact that the treated trees were not in any way injured and the effect on the scale was all that could be desired. The lime and salt wash, rather unexpectedly for the East, proved to be a very efficient insecticide, doubtless owing to the fact, however, that the weather conditions were exceptionally favorable. The lime emulsion indicated good results. The Bordeaux and oil mixture was less favorable, and the whitewash spray, while most promising in appearance at the outset, was valueless as to results in the outcome.

Crude and refined petroleum.—A series of plum, apple, and pear trees were sprayed March 22 with crude petroleum (43° Baumé), the applications being made thoroughly enough to completely wet the bark. The plum trees were thickly infested with *Diaspis pentagona* and the pear trees with the San Jose scale. Some of these trees had been pruned back heavily, and others were straggling trees 10 or 12 feet in

height. The application was made between 2 and 3 p. m. on a bright, dry day. At the same time a block of trees was sprayed with kerosene, or refined petroleum. The weather continued fair and dry for four days, and there was no rainfall of any amount prior to April 11. After the second day the kerosene had very largely evaporated, the treated trees showing only a very light discoloration. Trees treated with crude oil, on the other hand, were still very wet and oily looking. The full-grown female scales of *Diaspis pentagona* were thoroughly soaked and were permanently preserved, apparently, in the oil and had scarcely changed color and were not drying up. After six days a slight change in the coloration of the female scale insects began to be observed, the color slightly altering from light lemon to light orange. This change in coloration is a certain indication of the death and gradual drying up of scale insects, which usually change from lemon to orange and finally to brown or black in the different stages of drying after being killed by an insecticide. Three weeks after the application the trees treated with the crude oil were distinctly greasy in appearance and blackened by the oil. Trees sprayed with the pure kerosene gave no indication of having been treated at this time, the oil having entirely evaporated. Curiously enough, the grass growing about the trees treated with these oils seemed to be more affected by the refined than the crude oil, being somewhat yellowed. This grass had been sprayed pretty heavily with the oil to see what result would follow. Two weeks later—namely, five weeks after the application—the bark of the trees treated with the crude oil was still dark and distinctly oily. All the trees treated with oil were leafing out and blooming just as freely and fully as untreated trees. The grass, which had shown yellowing at the outset, had entirely recovered and was apparently uninjured, seeming to indicate, at any rate, that grass will stand a considerable application with both crude petroleum and the refined oil without being killed. This fact is interesting in connection with the use of this substance against white grubs on lawns. (See Pl. I.)

Lime, sulphur, and salt wash.—A mixture of this substance was prepared, differing slightly from the formula given in Farmers' Bulletin No. 19 in that the amount of lime was somewhat reduced, namely, from 40 to 30 pounds. This reduction in the amount of lime was made simply because in the ordinary formula the lime is very greatly in excess and remains as a pure lime sediment in the wash and has to be kept in suspension by agitation. Even as thus reduced there is still a considerable excess of lime. The formula followed was:

Lime	pounds	30
Sulphur	do	20
Salt	do	15
Water	gallons	60

The mixture was steam boiled altogether in barrels about four hours and applied March 23 and repeated March 24. The hot liquid was

DARK-COLORED TREES AT LEFT SPRAYED WITH CRUDE PETROLEUM; LIGHT-COLORED TREES IN MIDDLE FOREGROUND AND AT LEFT SPRAYED WITH LIME, SULPHUR, AND SALT WASH.

taken immediately from the barrels at almost a boiling temperature and sprayed at once on the trees. A series of experiments was also made with the preparation of this wash on a smaller scale, following practically the same formula. The products obtained were submitted to the Chemist of this Department for analysis, and the assistant chemist charged with the work was especially advised just what features were supposed to be desirable and what points the analysis should bring out. The result of this analysis, made by Mr. J. K. Haywood, of the Bureau of Chemistry, as reported by Dr. H. W. Wiley, Chief Chemist, is given in a footnote.[1] It is very interesting and valuable as showing the probable exact chemical nature of the wash in a dry climate and correspondingly also in a wet climate, in these respects practically substantiating the theory which the writer had announced several years ago. The practical application of this wash, as described above, was made to pear and plum trees, both infested with the San Jose scale, the plum trees being very thickly covered with the scale from top to bottom and the pear trees scaly from the butts upward three or four feet, scattering more or less over the whole tree. The plum trees had also more or less of *Diaspis pentagona*.

The question naturally arose, in view of the extreme heat at which the liquid was applied, whether any results gained might not be due to the high temperature of the liquid rather than from any insecticidal action. To test this matter some plum and peach trees covered with *Diaspis pentagona* were sprayed on March 27 with water at boiling temperature, or nearly so, the nozzle being held within 3 or 4

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[1] The lime, salt, and sulphur wash, as finally prepared, contains the following substances in solution: A large amount of (CaS) calcium sulphid, some of the higher sulphids of Ca (as CaS_3 and CaS_5), small amounts of ($CaSO_4$) calcium sulphate, and traces of ($CaSO_3$) calcium sulphite, and a large amount of (CaS_2O_3) calcium thiosulphate; also some of the excess of $Ca(OH)_2$ lime is in solution. The residue is composed of lime.

On evaporating down a portion of the wash, with blast and at a gentle heat, no decided change takes place. Calcium sulphid still remains, as does calcium thiosulphate. A small amount of sulphur is deposited (doubtless from the polysulphids of calcium), and the amount of calcium sulphate is increased to a small degree.

If such a wash were applied to trees in a dry climate, the various compounds formed would remain for a long time and only gradually decompose. Eventually, however, the calcium sulphid would decompose, most likely forming calcium sulphate and some hydrogen sulphid (H_2S), and the calcium thiosulphate would decompose, first setting free sulphur and calcium sulphite, which last would oxidize to calcium sulphate. The lime would change to calcium carbonate ($CaCO_3$) and the polysulphid would break down, yielding sulphur and calcium sulphid, which would in turn change as above.

In a wet climate the calcium sulphid and the calcium thiosulphate would soon leach out, leaving behind small amounts of calcium sulphate and a large amount of lime, which would in turn form insoluble calcium carbonate. In this latter case the tree would still remain white and appear to still have the wash upon it, but, in fact, very little other than the calcium carbonate would be left.

inches of the bark and the spraying being very thoroughly done. At a distance of 18 inches, as tested by spraying on one's hand, the mist or spray was barely warm; at a distance of 12 inches, fairly hot, and very hot at from 4 to 6 inches. The bark of the trees sprayed was cold to the hand as soon as spraying stopped. This hot-water spray brought to bear closely on the scale insects, it was thought, would kill them, although it would of course be impracticable to make such close-range application in general practice. On the contrary, however, the scales remained in a vigorous, healthy condition, and apparently did not suffer in the least from the warm douche.

The results, therefore, gained by the lime, sulphur, and salt wash may be properly ascribed, it is believed, to a true insecticidal value of the substance rather than to the temperature of the application. The trees treated with this wash remained nearly snow-white, little, if any, of the mixture being taken off by the light snow and rain of the 25th and 26th instant. Discoloration of the Diaspis began to be noticed on the 27th instant. On April 13 the Diaspis scale insects killed ranged between 20 and 50 per cent on the young, vigorous limbs. All were dead on the old trunk, where the wood was in a very unhealthy condition owing to the completeness of the infestation, both by the Diaspis and the Aspidiotus. The San Jose scale, so far as investigation could determine, seemed to be killed completely; no insects were found on the young, vigorous shoots or older wood. The trees were still whitened with the wash, which had not been carried off to any very great extent by the heavy rains of April 11 and 12. The infested trees, especially those that had been pruned back, made a very vigorous growth, and the fruiting and growth of the others were entirely satisfactory.

In this experiment, which differed so remarkably in results from other experiments made in the East with this substance, it must be noticed that the weather conditions were exceptionally favorable. The application was made on March 23, and no washing rains followed until April 11 or 12, the light rain and snow of the 25th and 26th of March being not enough to vitiate the wash particularly, as very little of the snow rested on the trees, and much that did gain lodgment fell or was blown off subsequently. A very light shower occurred on April 4, but the first heavy downpour and long rain occurred on the night of April 11.

This experiment would seem to indicate that if one could count on a week or two of good weather following an application, the lime, sulphur, and salt wash might be as beneficial in the East as on the Pacific coast. Its cost is inconsiderable compared with the other treatments for the San Jose scale.

During the summer of 1900 the writer spent considerable time in California and saw a great many deciduous orchards that had been

treated with the lime, sulphur, and salt wash. This treatment had been made in the winter or early in the spring, before the trees had begun to leaf out, and at the end of August the trees were still distinctly whitened by the application, there having been no rains in the interim to remove it from the bark. Under such circumstances it is plainly to be seen that this wash has the maximum chance of effectiveness, and that it is thoroughly effective under these conditions is beyond question. Its effectiveness is undoubtedly, in the first instance, chiefly due to the direct insecticidal action of the mixture; and possibly, secondarily, in protecting the tree by the limy and sulphurous coating, which remains for months and is undoubtedly distasteful to the young scales coming from old individuals which may have escaped, and perhaps retains enough of its insecticidal value to destroy many of them.

Bordeaux mixture kerosene emulsion.—This mixture, suggested by Professor Galloway, is an attempt to emulsify a small amount of kerosene in a comparatively large amount of Bordeaux wash. The formula used was—

	Gallons.
Bordeaux mixture	5
Kerosene	1

The two are churned together until the oil is emulsified. Some peach trees infested with *Diaspis pentagona* were sprayed with this mixture on April 14. At the time of the application the trees were just coming out in leaf and bloom. The weather conditions immediately following the application were favorable, no rain falling on the 15th or 16th. There was a good deal of rain, however, between April 17 and 22. This mixture seemed to have little effect on the trees, and also little effect, if any, on the scale insect. It must be remembered that the Diaspis has an unusually thick scale, and is therefore more than ordinarily protected and correspondingly immune from the action of insecticides, as was illustrated in the preceding experiment with the lime, sulphur, and salt wash, where not above 50 per cent of this Diaspis was killed by a wash that completely exterminated the San Jose scale. The testing of this mixture has not, therefore, been wholly satisfactory, and it is probably worth while to do some more work with it in the future with other scale insects.

Kerosene-lime emulsion.—This mixture, recommended to the writer by Professor Galloway some years ago and experimented with in a limited way at the time, was again brought to his notice by Professor Galloway, who prepared for his use an emulsion after the following formula:

Fresh lime	pounds	4
Water	gallons	5
Kerosene	do	1

Slack the lime slowly with small quantities of water in order to get a creamy solution. When thoroughly slacked dilute to 5 gallons, add 1 gallon of kerosene, and churn until emulsified (one or two minutes). This mixture was applied April 14 to a peach tree badly infested with *Diaspis pentagona*, and to several pear, quince, apple, and peach trees not infested with scale insects, the application to the latter being made more particularly to determine the effect of the wash on different kinds of trees. The application whitened the trees, not entirely, however, obscuring the bark. The treatment was very heavy and thorough. It is possible that more lime would have been an advantage, making a better emulsion and a slightly heavier wash. This treatment was made at the same time as the Bordeaux wash, referred to above, and experienced the same weather conditions. The effect of this wash on trees was not unfavorable, no injury being noted.[1] The Diaspis on the one scaly tree subjected to the wash were, for the most part, dead or dying by the 17th of April, the wash holding well and still coating the trees uniformly. This lime emulsion is worthy of a more extended trial, and it is hoped that others who have opportunity to test its effect on various scale insects will undertake experiments with it.

Whitewash.—At the suggestion of Dr. Howard and with the idea of determining the effect of the lime in the several lime washes used, a good sized plum tree thickly infested with *Diaspis pentagona* was subjected on the same date as the last two experiments to a thorough spraying with a strong whitewash, prepared by slacking 2 pounds of stone lime in a gallon of water. The application left a thick coat of whitewash on the tree, entirely obscuring the bark and leaving the plant snow-white. At the time of treatment the buds had not started. This lime wash held very well except that it cracked and scaled off a little in spots, due to the action of the wind. In the main, however, the bark of the tree remained snow-white and thickly covered for three or four weeks, in fact, at the end of the summer the lime still adhered to some slight extent. The tree came into bloom and leaf later on without any checking from the application. The adult female scales were not affected, apparently, at all by this application, rather to our disappointment, but it was still hoped that the lime coating would remain and prevent the young scales from settling on the bark. The young of this species, however, appeared very late in the spring and, unfortunately, before that time the lime had so cracked and scaled off in spots that little benefit was gained from its presence, and the second brood at least of this species again completely covered the tree. A lighter coating of lime as indicated by the lime, sulphur, and salt wash and the Bordeaux wash, and also the lime emulsion, adhered

[1] The infested peach tree first mentioned subsequently died, not necessarily, however, as a result of the treatment, but more likely in part from this scale infestation. The other peach trees were nor injured, nor did any of the other trees suffer from the wash.

PLUM TREE SPRAYED WITH A HEAVY LIME WASH.

better than the heavier coat experimented with in this instance and perhaps might have proven of some slight value in preventing the settling of the young scales. Further than this the pure lime wash appears to be of little value against scale insects, at least as indicated by this single test. (See Pl. II.)

The insecticide value of formaldehyde gas.—Some experiments were made in conjunction with Dr. E. A. de Schweinitz, of this Department, several years since to determine the insecticide value of formaldehyde gas. The results of these early trials indicate little, if any, value in this gas for the purpose named. This year opportunity was offered to test this gas in a much more satisfactory way. A patent generator having been devised by some local parties especially for germicide purposes, the owners were very anxious to have it tested, also to determine its value as a means of destroying insects. Under the writer's supervision, therefore, it was used in the first instance against insects affecting stored products. The gas was generated to three or four times the amount necessary for germicide purposes in the fumigating room of the Department which contained some grain badly infested with the Angoumois grain moth and some beans thickly stocked with the bean weevil. The gas killed some of the moths which were flying about thickly when the generator was put in operation, but the bean weevils were apparently not injured in the least by it and a good many of the moths were not killed. The generator was subsequently placed under a tented peach tree thickly infested with *Diaspis pentagona*. The generation of the gas in this instance was again in enormous quantity for the space inclosed, a quart of alcohol being converted. The effect on the tree was, however, most disastrous, the leaves showing almost complete withering as soon as the tent was removed and the tree dying shortly after. The scale insects were immediately killed by the application, and therefore not as a result of the death of the tree. The effect on the scale insects and the tree may have been, and was, very likely, due to the heat which the generation of the gas produces. This gas is generated by the imperfect combustion of wood alcohol in a burner or stove especially designed for the purpose. The insects in the fumigatorium and the scale insects on the tree were subjected to the influence of this gas between three and four hours.

A recent bulletin of the Hatch Experiment Station of the Massachusetts Agricultural College (No. 69) would seem to indicate that this gas has little or no value as a fungicide.

THE CARRIAGE OF DISEASE BY FLIES.

By L. O. Howard.

So much is said nowadays of the carriage of a certain class of diseases by mosquitoes that the agency of certain flies in the transmission of another class of diseases is apt, to a certain extent, to be

overlooked. The malarial germ has to pass through the body of certain mosquitoes before attaining its highest development or its full life history. So far as we know as yet, certain mosquitoes are necessary secondary hosts in the development of this disease germ. The malarial germ is an animal organism. It belongs to the group of animals known as Protozoa, and from analogy it is altogether likely that the as yet undiscovered germ of yellow fever will also prove to belong to the same class of parasitic organisms. The parasite which causes Texas fever in cattle is also analogous to the minute spore which causes malaria in human beings. It inhabits the blood just as does the malarial parasite, and is conveyed by a biting insect; in this case the cattle tick, just as the former is conveyed by certain mosquitoes. With diseases caused by bacterial organisms (which belong to the plant kingdom and not to the animal kingdom), a biting insect is not necessary for their transfer from a sick individual to a healthy one in the majority of cases. Such diseases are notably typhoid fever, cholera, and pulmonary consumption. With these diseases, and more especially the first two, the agency of non-biting flies as transmitters becomes important, and for this country their agency in the transfer of typhoid fever is especially important. It has been known for some time that flies may carry bacilli and bacteria on their feet. That was experimentally proven by allowing flies to walk over cultures, and after allowing them to walk upon sterilized media the same bacteria developed. Moreover, as early as 1888 it was shown by an Italian investigator that flies fed upon pure cultures of typhoid bacillus were able to transmit virulent bacilli with their excrement. Further early observations showed that flies are important agents in the transmission of Asiatic cholera.

Typhoid fever was astonishingly prevalent in the concentration camps in this country at the outbreak of the war with Spain, and the disease received a thorough investigation at the hands of a special commission of army surgeons appointed for the purpose. It was shown that although excellent preventive measures had been recommended in circulars issued by the Surgeon-General of the Army, these instructions were not carried out in many camps and that the excrement of the troops had not been properly cared for. Flies were found to swarm over the infected fecal matter in the pits and then proceed to the mess tents and feed upon the food prepared for the soldiers. This was convincingly shown by the fact that where lime had been sprinkled over the pits flies with their legs whitened by the lime were found upon the mess tables. In the report published by one of the members of the commission a number of significant and interesting facts relating to typhoid fever were brought out. It was shown, for example, that the virulent germs may be excreted by a person for some time before he is known to have typhoid. It was also shown that such germs may be found in the excrement for a long time after

apparently complete recovery of the patient. By the agency of flies which visit such excrement the bacilli may be carried far and wide to food supplies, and by their consumption may enter the digestive tract of many healthy individuals.

An investigation has been carried on in this office for the purpose of ascertaining just what flies breed in human excrement or are in the habit of visiting such substances, and, conversely, just what flies are found in dining rooms and kitchens where food is being served and prepared. These investigations have been conducted with the utmost care and in many different parts of the country. A very large amount of material was studied, and the detailed results were published in the proceedings of the Washington Academy of Sciences (Vol. II, pp. 451–604). Briefly summarized, it was found that the number of species of insects which breed in or frequent human excrement is very large. There are many beetles (44 species, and many hymenopterous parasites); none of these, however, are especially significant in this connection. Flies are the important creatures, and

FIG. 20.—*Musca domestica:* Puparium at left; adult next, with enlarged antenna; larva and enlarged parts at right—enlarged (original).

of these 77 species were studied. Thirty-six of them were found to breed in human fæces, while 41 were simply captured while visiting this substance or feeding upon it. Some, of course, were scarce and others were very abundant.

Now, in order to ascertain exactly which ones of these are important in the disease-bearing function more than 2,300 flies were caught in kitchens and dining rooms in different parts of the country from Massachusetts to California and from New York to Louisiana, and were all carefully examined. It was proven that of the excrement flies six species are found in houses in sufficient numbers to constitute them dangerous species. The most abundant species found in or on excrement do not occur in kitchens and dining rooms, but, as just stated, these six species are sufficiently abundant in both relations to become very dangerous.

At the head of these six species must stand the common house fly, *Musca domestica* (fig. 20). This insect constituted over 98 per cent of

the whole number of flies captured in kitchens and dining rooms, and while it was by no means one of the species most commonly captured upon excrement, it was shown conclusively that under certain conditions this insect may be a factor of the greatest importance in the spread of intestinal disease. In the most cleanly and best cared for portions of a large city these conditions do not exist. The admirable water supply and sewerage systems pertinent to such localities—the admirable water-closet facilities which sanitary plumbing has carried to such a degree of excellence—obviate in a large measure typhoid-transfer possibilities, yet, even in such places, where the vessels used in the sick room are not promptly disinfected and where by reason of neighboring stables house flies are especially abundant (since these creatures breed by preference in horse manure), the possibility may still exist, but in army camps where fæces are left exposed the house fly will and does breed in this substance in large numbers and in

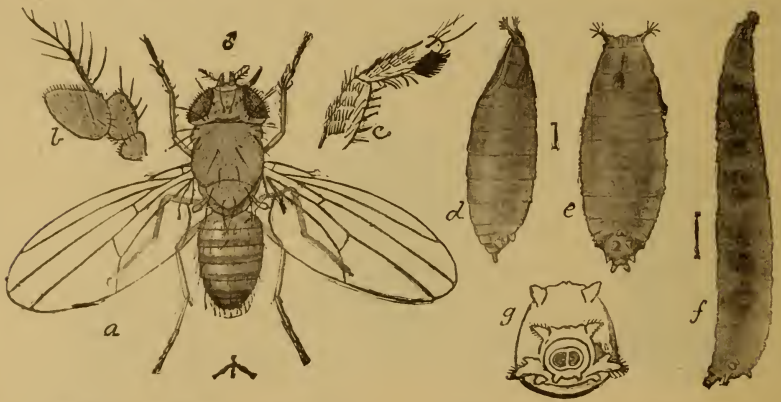

FIG. 21.—*Drosophila ampelophila: a*, adult; *b*, antenna of same; *c*, base of tibia and first tarsal joint of same; *d*, puparium, side view; *e*, puparium from above; *f*, full-grown larva; *g*, anal spiracles of same (author's illustration).

towns where the box-privy nuisance is still in existence (and this applies to very many farmers' houses in the country) the house fly is a constant source of danger. Moreover, in the low quarters of a large city where there is lax sanitary supervision, in the open lots surrounded by an ignorant population, fæces are frequently deposited in the open, sometimes in close proximity to kitchens, and thus may become very dangerous.

The other species of flies which are of especial importance are as follows: The little fruit flies of the genus Drosophila, and especially *Drosophila ampelophila* (fig. 21), which is so commonly found in houses in the autumn, attracted to overripe or partly decaying fruit, and which sometimes swarm in great numbers about the fruit stands in markets, is also an excrement breeder, and at certain times of the year becomes an important form in the disease-transfer relations. The species known as the little house fly (*Homalomyia canicularis* and *H.*

brevis (fig. 22), a small species sometimes with a light-colored abdomen, which is found commonly upon windows though not nearly so abundantly as the house fly, is also a dangerous species. The other most dangerous forms are the stable fly (*Stomoxys calcitrans*) (fig. 23)—a biting fly which looks so much like the house fly that it can hardly

FIG. 22.—*Homalomyia brevis:* Female at left; male next, with enlarged antenna; larva at right—enlarged (original).

be distinguished from it, but which has a piercing proboscis and bites severely—and the forms known as *Phora femorata* and *Sarcophaga trivialis.*

In brief, the results of the observations indicate—

(1) That in the interests of health, and especially as obviating the

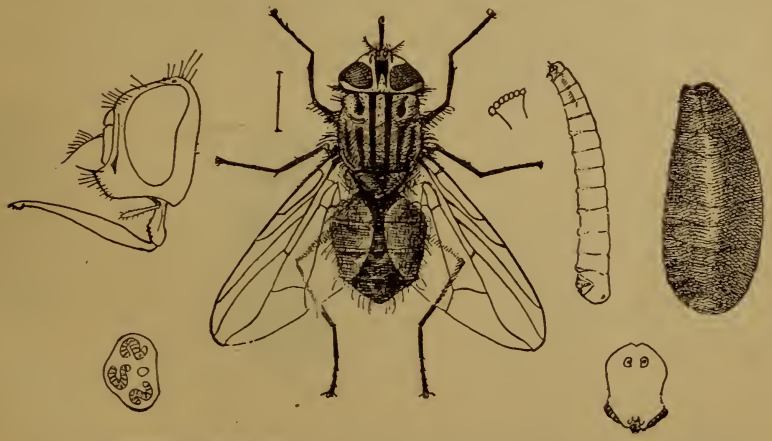

FIG. 23.—*Stomoxys calcitrans:* Adult, larva, puparium, and details—enlarged (original).

possibility of the transfer of typhoid fever by flies, the box-privy nuisance should be abolished wherever it exists, even with ordinary farmhouses, and some form of earth closet should be substituted, preferably one in which the contents can be removed and securely buried at very frequent intervals.

(2) Excrement should never be deposited in the open without being immediately covered with a thick layer of earth.

(3) In the low quarters of cities the especial attention of boards of health should be directed toward such open deposits, and such a deposition should be considered a punishable misdemeanor, and the regulation should be vigorously enforced. Of course, such offenses are generally committed after dark, and it is difficult to trace the offender, but the first responsible person who notices it should be required to report it to the police so that it may be removed or covered as soon as possible. Dead animals are so reported and cared for, but human excrement is much more dangerous than dead animals.

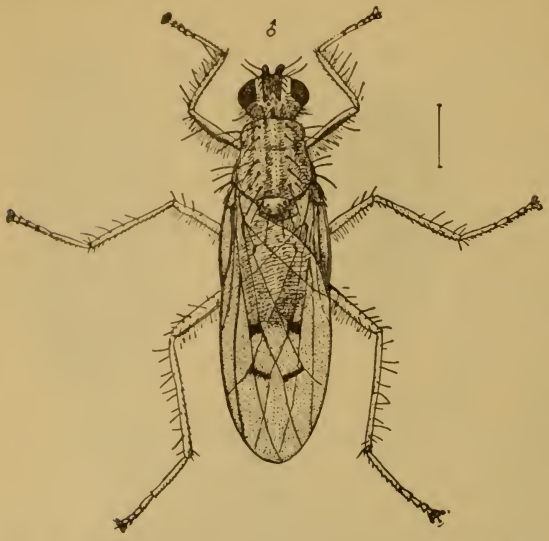

FIG. 24.—*Scatophaga furcata* (a common excrement fly): Male, with closed wings—enlarged (author's illustration).

(4) Every effort should be made by boards of health in cities and by private persons in the country to limit the breeding of the common house fly, and to accomplish this result a strict supervision of stables in which horses are kept should be carried on. As stated above, the great majority of house flies breed in horse manure. The breeding is rapid, and a small pile of horse manure may be responsible for an enormous number of flies. The writer has found by careful experimental work with many different insecticidal substances that chlorid of lime is the most efficient substance which can be applied to manure piles in order to destroy the maggots of house fly, but to treat an outdoor manure pile of large size with chlorid of lime would be an expensive matter. The writer has suggested, therefore, that some receptacle for the manure from each stable be

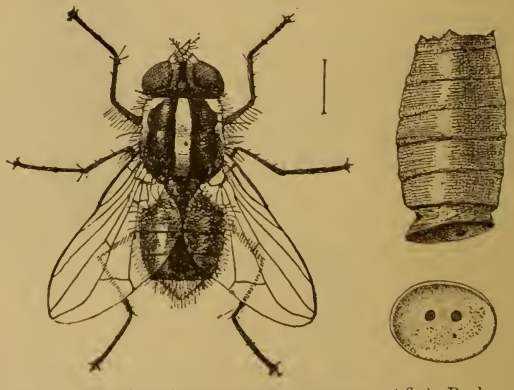

FIG. 25.—*Morellia micans* (a common excrement fly): Broken puparium at right—enlarged (original).

constructed, either in the form of a large closet with a door opening outside as well as one inside, or that a pit be made. The stable should be cleaned daily or every other day, and each time that a day's or two days' accumulation is added to the pile in the closet or pit a shovelful of the chlorid of lime should be thrown over it. When the manure is needed for the farm or garden it may just as conveniently be shoveled upon a wagon from the outside door of such a closet as described as from an outside pile. Thorough experiments were carried on some time since at the stable of the Department of Agriculture and it was found that by a little careful, inexpensive work of this kind the numbers of house flies of the whole neighborhood were rapidly and enormously lessened.

THE GREEN CLOVER WORM.

(*Plathypena scabra* Fab.)

By F. H. Chittenden.

One of the commonest insects about the District of Columbia is the Deltoid moth, *Plathypena scabra*, the larva of which, called the green clover worm, feeds on various leguminous plants, particularly clover. During the season of 1897, and again in 1899, this larva was frequently observed in connection with observations on insects attacking beans and peas in this vicinity.

RECENT OCCURRENCE.

Early in June, 1897, larvæ, mostly half grown, were observed on beans in the District of Columbia; also on soy beans August 18, and later nearly or quite mature on peas September 4. During autumn they were also observed on a species of tickweed (*Meibomia* sp.).

June 14, 1899, Mr. T. A. Keleher, of this office, brought specimens of the larvæ found on beans growing in the city of Washington. About the same time the writer observed this species of larva on vetch, a forage plant growing on experimental plats at this Department. Larvæ were still being found on vetch and bean until June 24. August 1 larvæ were found on Lima bean at Marshall Hall, Md., and August 10 on the same plant at Cabin John, Md., and during September larvæ were again obtained in great numbers on a species of Meibomia in the former locality.

Although it appears probable that this species feeds to all practical purposes exclusively upon the Leguminosæ, it is evidently capable of subsisting upon other plants, as was proved by the finding at different times by the writer of larvæ that agree with *Plathypena scabra* in every discernible particular on both strawberry and blackberry.

July 31 a moth of this species was reared from a larva obtained on strawberry in the District of Columbia. August 2 a second specimen was reared from a larva from the same strawberry patch. The

pupal condition in this case was passed in eight days, and the chrysalis was concealed in a rolled-up leaf of strawberry. Taking into consideration a previous observation on the larva's occurrence on strawberry in 1899, it would seem that this is a true larval food plant.

The moth is typical of the Deltoid group of Noctuidæ, a group of genera which derives its English name from the triangular outline of the moths when at rest, which is suggestive of the Greek letter Delta (Δ).

DESCRIPTION OF THE SPECIES.

The moth, like many others of this group, is remarkable by reason of its palpi, which are long and prominent, projecting in front like a snout, hence the name snout-moth. The hind wings are unusually broad. The color is variable, dull, sometimes very dark brown, form-

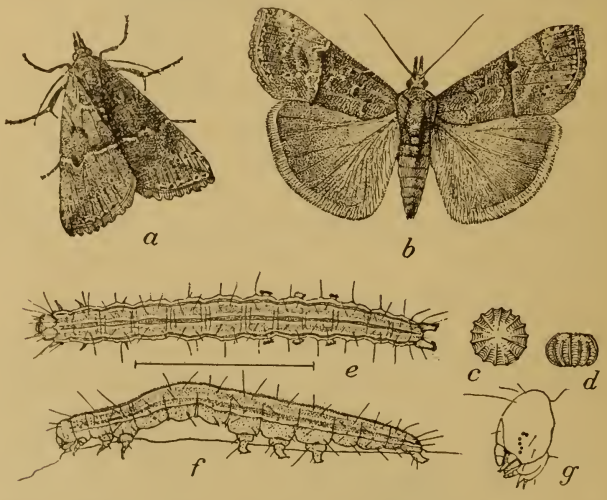

FIG. 26.—*Plathypena scabra:* *a*, moth in natural position with wings folded; *b*, same with wings expanded; *c*, egg from above; *d*, egg from side; *e*, penultimate stage of larva from above; *f*, same from side; *g*, head of larva—all enlarged; *c*, *d*, *g*, greatly enlarged (original).

ing the ground color varied with black and gray, arranged in the average specimen in a pattern similar to that figured in the illustration at *b*. A rather unusually light-colored individual was selected as the type for illustration in order to show the markings in full, since in dark specimens the pattern is often very obscure. A moth at rest is shown at *a*. The moth is also variable as regards size, the average expanse being about an inch and a quarter, although a series of specimens before the writer shows a still greater expanse, and one individual measures but five-eighths of an inch.

A technical diagnosis of the genus, detailed specific description, and bibliography is given by Dr. John B. Smith in his revision of the Deltoid moths (Bul. U. S. Nat. Museum, No. 48, 1895, pp. 110–112).

The distribution there accorded is "Nova Scotia to Texas, east of the Rocky Mountains." In the national collection is a series showing a distribution from Maine to Texas. The localities here represented and recorded include the following:

Maine; Williamstown, Mass. (Grote); Syracuse and New York, N. Y.; Boonton, N. J., "common everywhere" (Smith); Marshall Hall, Cabin John, Md.; Washington, D. C.; Virginia; St. Louis, Kirkwood, Mo.; Dayton, Ohio (Pilate); Hearne, Dallas, and elsewhere in Texas; Canton, Kirkwood, Miss.; Macon, Ga.; Alabama; Woodstock, Ill.; Volga, S. Dak., and St. Anthony Park, Minn. (Lugger). Also recorded from Winnipeg, Manitoba (Hanham).

About the city of Washington this moth is one of our latest as well as earliest species, individuals occurring commonly in the writer's experience about the Department buildings throughout the month of November, as late as the first week of December, and as early as March 10. An individual was observed flying on the last-mentioned date in a temperature of 51° F., which is about the lowest temperature in which any save exceptional species of insects are active.

This insect is a near relative of the hop-vine snout moth, *Hypena humuli* Harr., with which species it was, in fact, confused at an earlier date.

The green clover worm has not attracted much attention on account of its injuries, but good accounts of it have been given by Prof. J. H. Comstock in the Annual Report of this Department for 1879 (p. 252), and in the Canadian Entomologist for July, 1881 (Vol. XIII, pp. 137–138), the latter paper by Mr. Coquillett, of this Division.

THE EARLIER STAGES OF THE INSECT.

The egg.—Owing to an oversight, the eggs obtained hatched before a detailed description could be made. Dorsal and side views of the egg, however, were drawn, and are illustrated herewith (fig. 26, *c*, *d*), and from these a general idea of the egg as it looks under the microscope may be had. From memory the writer believes that the eggs were light gray in color and at least tinged with iridescence. Following are Mr. Coquillett's descriptions of the egg and of the first stage of the larva:

Globular, slightly flattened above, more decidedly so below; lower half smooth; upper half deeply grooved, the interspaces rounded and marked with fine transverse impressed lines; whitish, the upper half sometimes dotted with dark brown; transverse diameter, nearly 0.5 mm.

Measurements showed an average diameter of 0.5 mm and a height of 0.35 mm.

THE LARVA.

First stage.—"Body green; a dark-colored dorsal line, edged each side with a whitish line; a white subdorsal and stigmatal line; piliferous spots green, each bearing a short black hair; venter green; head polished green; body provided with only 14 legs."

In coloration this larva is somewhat suggestive of the common cabbage looper, *Plusia brassicæ*, but the form is entirely different, being much more slender, and although the species is a semi-looper, like Plusia, it is not at all likely to be mistaken for it. The colors are somewhat more constant in the several stages.

The penultimate stage.—The larva is green and white striped and is in its most characteristic colors when in the penultimate stage, as it loses its striation to a great extent when fully matured. The general color is clear, translucent green, a shade or two lighter than the bean or other leguminous leaves upon which it feeds. It is about ten times as long as wide and segmentation is well marked. The body is widest about the middle, tapering gradually toward each end, the last segments being narrowest. The head is of nearly the same color as the remainder of the body, a trifle lighter and less translucent. The entire surface of the body is sparsely covered with long, slender, and dark brown hairs. The piliferous warts project above the surface, but otherwise are not noticeable, being only a very little lighter in color than the body. The thoracic legs are nearly the same color as the head. There are only three abdominal prolegs. The anal prolegs are long and project well beyond the last segment. There are six white stripes on the body which alternate with the general green. The green dorsal line is a little darker than the general color of the body. There is a rather wide white stripe each side, a latero-dorsal narrow white stripe, and a broader irregular lateral stripe. The prothoracic folds are strongly pronounced, particularly in the region of the legs; abdominal folds also pronounced. Length in this stage, 20–24^{mm}: width, 2.4–2.6^{mm}.

Last larval stage.—After the final molt the larva usually loses to a great extent its striated appearance and becomes nearly uniform paler green in color as well as stouter. The head is sometimes somewhat yellowish, as is also the first thoracic segment. The ocelli are twelve in number, arranged at the sides of the head in three pairs, as shown in the figure at *g*.

In alcohol the larva loses its color, being apt to be turned black unless first boiled in water, when the color becomes milk white. Length at maturity, 25–29^{mm}; width, 2.8–3.0^{mm}.

The penultimate stage is figured because, as previously remarked, more characteristic of the species than the final stage before pupation.

THE PUPA AND COCOON.

The pupa.—The pupa is dark brown and presents rather good characters for description, but as this stage has previously been very fully characterized by Professor Comstock, in the report of this Department for 1879, his description is transcribed:

> Rather stout, dark mahogany-brown. Wing sheaths and crural sheaths closely soldered; the former obtusely rounded and extending to the end of the fifth abdom-

inal segment. Stigmatal tubercles quite prominent. Dorsum of thorax and wing sheaths coarsely shagreened. Dorsum of abdominal segments rather sparsely punctulate, the posterior border of each segment being smooth and shining. The anal segment at its end is furnished with several (a variable number) minute recurved hook-like spines. From the apex of the head to the end of the fourth abdominal segment the dorsum is elevated into a slight ridge, more marked upon the abdominal segments than upon the thorax.

The cocoon.—Pupation takes place in a somewhat loosely built but not fragile cocoon, those in our rearing jars having been formed just upon the surface of the earth. They were constructed of particles of sand joined together with silken web and sometimes attached to leaves or other vegetation. They are of elliptical form and somewhat depressed, and measure on the outside about 16–18^{mm} in length and 6–8^{mm} in width.

ON THE HABITS OF THE SPECIES.

In the report of this Department for 1879 (*loc. cit.*) attention was called to the abundance of the moth in the District of Columbia during the winter of 1878–79, when it was seen flying on warm, sunshiny days, while in the summer months larvæ were found so commonly upon clover "that in many places one could hardly make a swing of the beating net through the grass without capturing one or more of them."

The larvæ are quite active, and when disturbed either let themselves down to the ground by means of their webs or quickly throw themselves from their food plant after the manner of many Pyralids. The moth is a rapid flyer, and although normally keeping in concealment, is often found exposed on the walls of buildings and on windows in conspicuous places.

In Bulletin No. 3 of the United States Entomological Commission the late Professor Riley had a short note on this species, in which he stated that the larva fed also on locust (Robinia), and gives some notes on the hibernation of the species. He says that this insect hibernates in the imago state all over the country and that in Missouri the chrysalis may also be found under bark in winter, but the habit of hibernating in the pupa state is doubtless exceptional. The late and early appearance of the moth would alone indicate that hibernation takes place in the mature condition.

Mr. Coquillett traced the insect through its various stages at Woodstock, Ill. The periods were as follows: From the deposition of the eggs to hatching, four to six days; larval stage, twenty-five days, and from the spinning of the cocoon to the issuance of the imago, twelve to fourteen days. Only two larval molts were observed, the time from hatching to the first molt being seventeen days, from the first to

the second molt, three days, and from the second molt to the time of spinning the cocoon, five days. Several individuals which were kept under observation at this office transformed from larva to pupa June 23, and the moths issued July 4, having passed eleven days as pupæ.

Of the number of generations of this insect Mr. Coquillett observed that there appeared to be only two broods in a season in the latitude of Woodstock, Ill., and Professor Comstock says there are certainly two and perhaps three broods in a season. The writer's observations tend to show at least three well-marked generations for the latitude of the District of Columbia, the first generation usually developing toward the middle of June, the second early in August, and the third sometime late in September or early in October. There is no indication, however, of any great regularity in the issuance of the moths, since they have been reared at this office at various other times than on the dates mentioned. The exact dates of issuance as recorded in our notes are: June 12, 15, 23, 28, 30; July 4, 8, 16; August 1; September 2, 5, 6, 25, 27. Moths, however, as has previously been observed, have been found much earlier than in June and as late as the first week of December, at the latter time on several occasions, once when the thermometer registered 54° F.

NATURAL ENEMIES.

A single parasite was reared from the pupæ of this moth September 7, 1899, and on being referred to Mr. Coquillett was identified as the the Tachinid fly, *Exorista blanda* O.-S. This is the second natural enemy that has been observed for the green clover worm to the writer's knowledge, the other being a chalcis fly, *Euplectrus platyhypenæ* How. The latter was reared at this office July 11, 1882, from material from the District of Columbia. (Bul. 5, o. s., Div. Ent., p. 27.)

REMEDIAL TREATMENT.

Ordinarily the injuries effected by this clover worm are so inconsiderable as not to necessitate any special line of treatment. It is one of several common insects that live habitually on clover and which by their combined effort devour a certain proportion of the clover crop over considerable territory. Poisons are, of course, out of the question in pasture land and in clover fields, and on lawns there can be little doubt that frequent mowing with a lawn mower is all that is necessary, since the insects live freely exposed upon their food plants during the day and do not resort to the plans of concealment resorted to by cutworms.

REPORT UPON AN INVESTIGATION OF THE CODLING MOTH IN IDAHO IN 1900.

By C. B. Simpson, *Special Agent.*

The following report upon an investigation of the codling moth in the State of Idaho is made in accordance with the authorization of the Secretary of Agriculture and instructions of the Chief of the Division of Entomology:

Upon reaching Boise I commenced a rigid inspection of orchards in that vicinity and observed the methods used against the codling moth and the results of the same. Numerous cages were started for the study of the life history of the insect. Many articles upon the insect were published in the leading papers. These articles were copied by many of the other papers. I also had a long conference with Professor Aldrich, of the University of Idaho, in regard to the codling moth.

EXTENT OF INJURY.

Indications of damage caused by the codling moth were seen in every section of the State which I visited where apples are grown. By report the moth is present all over the State, except in a few limited localities in the mountains. From my observation I can say without hesitation that 50 per cent of the apple crop of Idaho was destroyed by the codling moth in 1900. According to Mr. McPherson the loss in South Idaho and about Lewiston for the districts was 75 per cent.

In untreated orchards I found a great difference in the percentage of apples infested. The injury ranged from 40 per cent to practically 100 per cent. In the small orchards and isolated trees in and about Boise I have been unable to find sound apples. In the larger untreated orchards which were more or less isolated I found in some cases the injury to be about 40 per cent. In orchards well cared for I estimated the injuries to vary from 50 to 0.05 per cent. In an orchard near Boise that was sprayed and banded 44 per cent of the crop was lost. In an orchard in the city of Boise that was sprayed with arsenites and banded the loss was only about 20 per cent. In more or less isolated orchards that were well cared for the loss was found to be 10 per cent or less. In another orchard near Boise which had been sprayed three times and not banded the injury was from 90 to 98 per cent. In an orchard that was only banded the injury was about 60 per cent.

About Lewiston the damage is somewhat less than in the southern part. Professor Aldrich tells me that in 1899 the damage about Moscow was 21 per cent, while in 1900 it was only about 10 per cent.

I have been informed that in small valleys in the mountains the codling moth does no damage. The apple is the fruit most infested. The injury to pears never exceeds 0.05 to 10 per cent.

INTRODUCTION AND SPREAD.

Previous to 1887 the codling moth was practically unknown in Idaho. It was probably present before that time, but did so little damage as not to be noticed.

The moth, without doubt, came into the northern part by way of the Snake River valley. Its spread was rapid, although checked to some extent by the long distance between orchards.

The sections which are shipping apples are now all infested. The newer orchards are more or less free, but can not remain so very long.

RESISTANCE OF VARIETIES OF APPLES.

Only scattered observations were made upon this point, and these do not harmonize. Some of the varieties in order of damage sustained are:

1. Pewaukee (always badly infested).
2. Spitzenberg.
3. Bell-flower.
4. King.
5. Gravenstein.
6. Wealthy (very variable).
7. Ben Davis (very variable).
8. Rome Beauty (very variable).
9. Winesap (but little infested).

This question is believed to be one of the most important to be worked out, as in general the apples given as least infested are the best varieties for Idaho.

LIFE HISTORY OF THE CODLING MOTH.

The life history, as usually given, applies to the insect in a climate far different from that of Idaho. On this account I spent much time in studying the variations in the life history.

THE EGG.

The eggs can be found at any time during the summer, either upon the fruit or upon the upper surface of the leaves. In certain orchards the eggs were almost entirely upon the fruits; in orchards near by they were nearly all upon the leaves. Where apples were in abundance there were but few eggs upon the leaves, and where apples were scarce but few eggs were upon them. Apparently the moth prefers to lay its eggs upon the fruits.

The eggs have been described as whitish, milk-like spots. They adhere closely to the fruit or leaf, and even after hatching the shells remain for a long time. When the egg is a few days old a brown horseshoe-shaped band appears indicating the embryonic larva.

THE LARVA.

In from about six to eight days the larva is fully formed and breaks its way out of the shell. Most of them come out through the top

covers, but a few were observed in which the larvæ had evidently emerged through the lower surface of the egg next to the apple or leaf.

The young caterpillar is about one-fifteenth of an inch in length and is of a semitransparent color. Later dark spots appear around the hairs.

The young larva, after piercing the apple, makes a shallow mine just under the skin. Those mines can be easily recognized by the lighter color and by the excrement which is cast out. The larvæ which enter by the calyx also take their first few meals at the surface inside the calyx.

By counting infested apples on unsprayed trees I found that about 60 per cent of the larvæ of the first brood enter at the calyx end. In the later broods but few enter the calyx end. Many enter the apple at the stem end. The greater proportion, probably from 60 to 90 per cent, enter at any part of the apple. A favorite place of entrance is at the point where two apples touch.

At the end of four or five days the larva commences to tunnel toward the central portion of the fruit. Arriving at the center, it commences irregular excavations, which are filled with excrement, the pellets of which are bound together by silken threads. Surrounded by abundance of food, the insect grows rapidly, casting its skin many times. I have found many burrows, sometimes as large in diameter as a full-grown larva, in which no larva could be found; therefore, I believe that sometimes a larva feeds upon more than one fruit. In all cases where fruits touch they are both injured.

While one larva usually feeds upon but one apple, one apple may be eaten by many larvæ. A large apple was found with thirteen worm-holes in it, both entrance and exit, and three larvæ, of various sizes, were feeding inside. It is a very common occurrence to find from four to seven holes in an apple. These different holes are usually made by insects of different broods. In a badly infested orchard the earlier apples rarely had but one insect in each. A larval stage of from ten to fourteen days, as given by Professor Card, is, I think, nearly correct for Idaho.

On summer apples and most fall apples the effect of the insect is to cause the fruit to ripen prematurely. In the winter varieties, such as Winesap, there is no such ripening. In all cases the fruit is rendered unfit for use. When full grown the larva eats its way to the surface of the apple. The burrow is kept closed by frass, or sometimes an adjacent leaf is fastened over the hole with silk. Having eaten as much as it desires, the larva pushes out the plug or removes the leaf and leaves the fruit. In warm weather the worms, for the greater part, leave the apples in the early evening or night; but in colder weather, in the fall, they emerge during the heat of the day. If the fruit has fallen,

the larva crawls along the ground to a suitable place to spin its cocoon. The worms have two modes of leaving the fruit left on the tree. In some cases they drop by a silken thread to the ground. I have observed a larva hanging by this thread, and many threads were noted hanging from the trees. The other, and by far the most common method, is for the larvæ to crawl from the apple to a branch and thence to the tree trunk.

Upon leaving the apple the worm immediately seeks a place to spin the cocoon. The place usually selected is under rough, loose bark, in cracks or holes of the tree trunk and larger branches, under bands or cloths on the trees—in fact, in almost any dark and tight crack or crevice. Many cocoons are placed in cracks in the ground about the trees. This is especially true when the tree trunk is smooth and offers no suitable place. Mr. McPherson says he has found many cocoons among the clods of earth in his orchard. Where apples are stored the worms spin the cocoons in the boxes. I have found as many as 30 cocoons in and on one box. Having found a satisfactory place, the larva spins a tough silken case. In the earlier broods the larvæ spin their cocoons quite thin and do not usually use other substances than silk in its construction. The last brood, however, build their cocoons thicker, and in nearly all cases hollow out a space for it and mix little pieces of wood, bark, or cloth with the silk. The larva is bent in a U shape in the cocoon. If the cocoon be destroyed the larva will set to work immediately to build another or to repair the old one if it be not completely destroyed.

THE PUPA.

In from three to five days in the summer the larva sheds its skin and becomes a pupa. In the last brood the larval stage lasts until the spring. The pupa is at first of a yellowish color, later becoming brown and then bronze in color. When the moth is ready to emerge, the pupa, aided by the spines on the abdominal segments, wriggles itself out of the cocoon. I have seen empty cases that had been thrust through heavy muslin which was used as a band.

These empty pupal skins are familiar objects upon infested trees. I once counted 50 of them protruding from under pieces of bark in a space of about a square foot. During the warmer season the time spent in the cocoon is from seven to eleven days. Many stay in a longer, but very few a shorter time. The last brood stay in the cocoon about eight months.

THE MOTH.

The moth is a beautiful insect whose front wings have the color of brown watered silk, and are crossed by lines of brown and gray scales. Near the tip of the wing is a large bronze-colored spot. The

hind wings, which are concealed during repose, are of a grayish color. The moth varies in size, but never expands over an inch. The sexes may be distinguished readily by the fact that the male has a streak of black hairs upon the upper surface of each hind wing, and upon the under surface of each front wing there is a long blackish spot. The relative number of moths of each sex is about equal.

The adult insect is rarely seen. In my summer's experience I saw but five. These were either resting upon the upper surface of the leaves or were upon the trunk or larger branches. In warm evenings by aid of a light I saw a few flying about the trees.

It has long been known that the moth is not attracted to lights. I examined the contents of an electric (arc) light globe that was near an orchard without finding a single codling moth.

It has been observed that the moths feed upon apple juice, and I saw two moths feeding upon the juice of a crushed apple. Mr. Hitt tells me that it is common to find moths about cider mills. I have found that if a piece of ripe apple was placed in a cage of moths they would lay eggs in abundance, and if the apple was wanting no eggs or but few would be laid.

After laying eggs, the moths in cages die in about a week.

BROODS OF THE INSECT.

In view of the fact of the differences of altitude and temperature in Idaho there must exist a corresponding difference in the number of broods.

Upon arriving at Boise I immediately commenced work upon this question. I found the overlapping of broods to be something remarkable. From July 7 to about September 1, I could find in the field all stages of the insect except the adult, which I could breed in cages. From my band records I find that while I kept records there were larvæ going under bands every day.

From the records of Mr. Ayers, of Boise (as given later), we find that in 1897 there were larvæ under the bands every week from June 25 to October 19. To sum up, we have every day throughout the season moths emerging and laying eggs, eggs hatching, larvæ coming out of apples and spinning cocoons, and larvæ changing to pupæ.

This fact, together with the number of broods, certainly explains why the codling moth is more injurious in the West than in the East. The overlapping can be accounted for by the difference in rate of development of different individual insects.

Professor Aldrich says that in the section from Boise to Weiser and about Lewiston there are at least three broods, and part of a fourth was observed at Boise this year (1899). Mr. McPherson, Mr. Hitt, and others have arrived at the same conclusion. Without doubt the number of broods in Fremont and Bingham counties is less.

The following are the band records taken by Mr. Ayers, of Boise, on 140 trees:

Date.	Larvæ.	Date.	Larvæ.
1897.		1898.	
July 2	862	July 5	1,118
July 9	704	July 13	2,201
July 16	1,268	July 20	2,020
July 23	740	July 27	1,454
August 2	606	August 3	1,335
August 9	290	August 10	963
August 18	580	August 17	1,095
August 25	684	August 24	1,125
September 2	1,526	August 31	1,580
September 10	1,227	September 7	1,474
September 21	1,340	September 14	1,860
October 4	1,642	September 22	1,965
October 19	778	October 1	1,594
		October 10	1,125

From the preceding record, from that of Professor Aldrich taken at Juliaetta for 1899, and my own I have compiled the following table:

	1897.	1898.	1899.	1900.
First brood:				
Maximum	July 16	July 13	July 21	July 15
Minimum	Aug. 9	Aug. 10	Aug. 12	Aug. 4
Second brood:				
Maximum	Sept. 2	Aug. 31	Aug. 18	Aug. 25
Minimum	Sept. 10	Sept. 7	Sept. 4	Sept. 1
Third brood:				
Maximum	Oct. 4	Sept. 22	Sept. 25	Sept. 25
Minimum				

From these records, supplemented by observation, I can say definitely that there are three broods in the vicinity of Boise and the greater part of the Snake River Valley.

As to the fourth brood I have no definite information at hand. Several growers have told me that such a brood exists in part. At certain periods it is impossible to say to what brood an insect belongs. For instance, in 1900, if a half-grown larva was found October 4 it would be impossible to know whether it was the last of the third or the first of the fourth. When cold weather comes, there are many interesting things apparent. If young larvæ are left in the fruit on the ground, they evidently perish. However, if taken inside with the apples they complete their development, and if not destroyed insure a crop of moths for the following spring. About September 5 it was noticed that the larvæ that had spun cocoons were not transforming, but were still in the larval state, while those that had reached the pupa state were developing slowly and the moths were emerging. It is evident that it takes a higher temperature for the insect to change from larva to pupa than from pupa to adult.

MOISTURE AND HEAT.

There is great mortality among the eggs of this insect, the direct rays of the hot sun causing many to die.

In the larval state, especially when young, there are many agencies of destruction. I have found tips of branches upon which there was but one apple. On the leaves near by there were half a dozen or so hatched eggs, while the apple contained but one larva. In one case the larva would have to crawl 20 feet before finding another.

In many cases I have found from 2 to 5 per cent of the larvæ dead before they had commenced their burrow to the center of the apple from the mine under the skin. There are very few deaths due to fungus and bacteria in the dry regions. In many orchards, in which the water used for irrigation is allowed to stand around the trees, the number of infested apples is markedly less than in those orchards where irrigation is by ditches. Also one does not, as a general rule, find as many worms under bands on trees which have moist soil around them. The only explanation is that the moisture either causes the insects to die by fungus or bacteria or to seek other places. This method, however, has grave disadvantages, since water allowed to stand in an orchard will sooner or later kill the trees.

NATURAL ENEMIES.

I did not succeed in finding any egg parasites, but within a pupa I found a pupa of a Hymenopter, but the parasite did not emerge. It was probably a Pimpla. In another pupa I found many pupæ of a Hymenopterous parasite, which died before becoming adults. Under some neglected bands were many silk cocoons, probably of a Microgaster. Although they are not bred directly from the codling moth, there is little doubt but that they were from this insect.

While the larvæ are seeking a place to spin their cocoons in the daytime they are preyed upon by ants and birds. Chickens allowed in an orchard eat them readily. Often I have observed holes in the bark, and upon examination found empty cocoons. One evening several bats were noticed flying around apple trees and probably feeding upon the moths.

PREVENTIVE MEASURES.

One of the best preventive measures is following the best general horticultural practices, such as keeping the soil and trees in healthy and vigorous condition and keeping a close watch upon the orchard. If a fruit grower has no codling moths, what should he do to keep them out of his orchard? The answer to this question has many conditions, according to location, etc. To begin with, every grower should be familiar with this insect in all its stages and know how to fight it. An orchard may be at such an altitude that the insect will not be a very serious pest. In this case the small amount of damage should not be an excuse for letting it alone. It would be well for the grower to be

careful in importing infested fruit and to exercise utmost vigilance in watching his orchard, and if the moth is found, even in small numbers, no expense should be spared to apply the proper remedies immediately.

One source of trouble that can be easily prevented is that when apples are stored the larvæ emerge from the fruit, spin their cocoons, and upon emerging as moths in the spring find easy access to the orchard. I studied two well-marked cases of this. At Mr. C. M. Kiggins's place apples were stored in boxes in a cellar in which there were open ventilators. I found many old cocoons in and about these boxes. When I examined the orchard, July 9, I found that in trees nearest the cellar practically all of the apples were infested. In going from the cellar a noticeable decrease was observed, and in the farthest part of the orchard the injury varied from 5 to 30 per cent.

In the well-kept orchard of Hon. Edgar Wilson a similar case was noted.

These examples show the futility of remedial measures when the moth has such a start. Both Mr. Wilson and Mr. Kiggins are fully aware of the above conditions, and will take care that the mistake is not repeated. Either of three courses may be followed: To fumigate with hydrocyanic-acid gas while the larvæ are in the cocoon, to put screens over the holes and crush the moths which will collect there, or not to store apples on the premises.

In some cases picking the apples early to escape a coming brood is practiced. If the stages of the insect are known, this method may be followed to much advantage.

REMEDIAL MEASURES.

In fighting this insect, the first question which presents itself is, In what stage can the insect be best attacked, and how?

As a result of the work that has been done on this subject, it is evident that any mixture strong enough to kill the egg will injure the tree. Further work may throw more light upon this subject.

At two periods in this stage the insect is vulnerable, and a larger portion of the remedies have been used at these periods.

After the young larvæ hatch, and before they have started for the center of the apple, has long been recognized as the most vulnerable point in the life of the insect. At this point spraying is a most effective remedial measure.

I found that in Idaho the fruit growers were using many kinds of spraying solutions, with varying results.

A patent mixture, composed largely of carbolic acid and coal tar, was used by some. This solution is supposed to have a smell about it that keeps the moth away from the tree. The best I have seen this solution do, with several excellent sprayings, in conjunction with

bands, was to save 66 per cent. I believe that what good effects are derived from its use are due to the killing of the larvæ with which it comes in contact.

Many of the fruit growers add an arsenite, usually paris green, to the carbolic compound. The results with this mixture are varying.

Others have used kerosene in the arsenite, thereby combining both poisonous and contact insecticide. One grower used this combination, and writes me that "There are no wormy apples to be seen" (in his orchard), and that the apples injured by all sources amounted to only about 0.05 per cent.

One difficulty is to get these different ingredients to mix well. Whale-oil soap is used in combination with other sprays, but I could find no facts in regard to the results of its use.

By far the greater number of growers use the arsenites alone. Of these arsenites paris green is most used, in the proportion of 1 pound to 150 gallons of water, with from 1 to 2 pounds of freshly slacked lime.

Some are using London purple, and others are using a combination of London purple and Paris green. Many are using the lime arsenite with excellent results. In fact, wherever any of these arsenites are used intelligently good results are obtained. Some growers are prejudiced against certain of these arsenites on account of past experiences. In two cases I found that they had omitted the lime, and in both cases the foliage was badly burned.

My observations have led me to believe that it makes but little difference as to what arsenite is used if it is well applied.

The pumps used were of all kinds and conditions. Many were using nozzles which threw a coarse spray that was valueless. The time for spraying is as essential as the spraying itself, and I wish that this fact could be impressed strongly upon the Idaho growers. One can readily see that a spray would do but little good when the maximum of a brood are going under bands, compared with a spray when the maximum of a brood is hatching from the egg. To secure good results, there must be at least three sprayings, and in extremely bad cases it is advisable to spray six times.

If the injury for the previous season was large, I would advise two sprayings while the calyx remained open—one immediately after the blossoms have fallen and the other in about a week. If, however, the injury of the previous season was not large, one spraying from five days to a week after the blossoms have fallen may answer. In all cases I would advise the two sprayings, as it is well to be on the safe side.

It has become one of the best known principles of spraying that these first sprayings are the most efficient, and if it were not for the

number of broods in Idaho these, I believe, would be sufficient. In short, the poison is put in the calyx cup, the calyx closes, and when the young larva enters the calyx for its first few meals it gets some of the poison. As about 60 per cent enter the apple at this point, it is very plain that this is the golden opportunity in this combat. Professor Aldrich finds that 41 per cent of the larvæ entering the calyx end are destroyed by this spraying. An insect killed at this time not only saves the apple, but reduces the number of the insects of the following broods. By a single spraying and by banding one prominent grower tells me that he can save 50 per cent of his apples. Many people spray only once a season, and consequently the effect of it is lost later in the season. If rains wash off these sprays, they should be repeated immediately.

The next spraying should be done when the second brood is entering the fruit. Find the maximum of the preceding brood going under the bands and spray about two weeks later. It would probably be better to spray a few days earlier than two weeks. A few growers watch the increase of spots on the apples. The later sprayings should be determined in the same way. Other sprayings can be done with profit on account of the overlapping of the broods, but they should be made as near the maximum of egg-hatching as possible. In fact, late in the season, when the maximum is poorly defined, a spray is more or less effective at any time. Last year (1900) the dates, according to band records, for most effective spraying were June 10–15, July 27, and September 5. No inflexible rule can be given for these dates, as each grower has different conditions to meet and seasons vary. Each grower must determine these dates for himself. The greater number of the growers simply space off the season and spray at empirical times, without regard to the stage of the insect, and obtain, as a consequence, poor results.

It has been clearly demonstrated that these few sprayings alone are not always sufficient to control the insect. If the sprayings were made every week, the insect could be controlled, but this is too expensive. The spray is effective only for a short time, and must be supplemented by something to take the insects which enter the fruit between the sprayings. Banding has been found to be the most efficient in this connection.

Many people object to the use of arsenites for later sprayings on account of the liability of poisoning those who eat the fruit. I believe this objection is not well taken, since one would have to eat an enormous quantity of apples to be affected. If a large amount of poison remained in the hollow around the stem of an apple, there might be some danger. I have eaten many apples upon which the spray still remained and experienced no evil effects.

During the growing period of the larvæ the infested apple may be

picked from the trees and either destroyed or fed to stock. However, this method is so expensive in a large orchard that it is out of the question. If the people in the towns who have apple trees more for shade rather than for the fruit would destroy their apples, they would aid materially in reducing the number of the pest, and would also eradicate a constant source of infection.

In the "windfalls" there is another chance to attack this insect. In many orchards the fallen apples literally cover the ground. Careful experiments have shown that about 50 per cent of these fallen apples contain larvæ. Many methods may be used in the destruction of the windfalls. The best and easiest applied is to allow hogs or sheep to run in an orchard. These animals soon become very efficient and keep the ground well cleared. In doing this, the grower not only gets rid of the apples, but gets his stock fed upon food that would otherwise be wasted. Many growers collect the windfalls at stated intervals and make cider from them. At best, destruction of the windfalls is only partially effective, but is a useful ally to other methods.

When the larvæ are full grown, and after leaving the apples are seeking places to spin their cocoons, another point of attack is opened.

Banding is simply providing a suitable place for the insect larva to spin its cocoon. Temporary bands of hay or paper, which are afterwards burned with the larvæ, may be used. Many kinds of permanent bands, which are not destroyed, have been devised, but a piece of cloth from 4 to 8 inches wide, folded lengthwise once, and placed around the trees is the most efficient and economical. These bands can be made of any thick dark-colored cloth, such as pieces of old clothing or burlap. Professor Aldrich recommends brown canton flannel. I have seen many bands that were but strips of white muslin, which did not offer an attractive place for the insect, and thus the purpose for which they were put on was defeated.

It is highly essential that before a band is put on a tree all places where the larvæ could spin up be removed. The rough bark should be removed from the tree, and all holes should be filled with either mud or mortar. I have obtained twenty larvæ from a hole in a tree. If a large cavity is present in the tree trunk, bands should be placed above and below.

The bands should be placed around the trunk of the tree from about 1½ feet above the ground. If the tree is large it is best to put a band on each of the branches. Two bands on a tree trunk are better than one, but if the tree is well scraped and the holes filled I think one wide band is sufficient. A convenient and time-saving device for fastening the bands on, is to drive a small nail into the trunk and cut off the head diagonally so as to leave a sharp point. This nail is allowed to remain in the tree and the ends of the band are pushed over it.

Apparently banding is more efficient in Idaho than in any other

State where experiments have been made. The number of larvæ caught is sometimes very large. Professor Aldrich records that the highest number he found on one tree in a week was 110. Various persons have found from 50 to 190 on neglected trees. I once found 170 under a neglected band and a cloth in the crotch of a large tree. In 1898 Mr. Ayres obtained from 6 to 15 worms per tree throughout the season. In the maximum in September I have obtained on large trees as many as 20 to 30 daily for a few days, in a neglected orchard. Professor Aldrich records that in his banding experiments he obtained 215 worms per tree for the season of 1899.

The worms which have been collected under bands should be killed every seven days. Six days is recommended by some. I think six days too short as but few moths emerge before seven or eight days. However, the person who is killing the larvæ can easily tell whether the time is too long or too short. If old pupal skins are found the time is too long, and if no larvæ have changed to pupæ the time is too short.

Many ways of killing the larvæ have been used, such as burning temporary bands, plunging the permanent bands in hot water, or running them through a clothes wringer. I find that the majority of fruit growers in Idaho simply crush the worms, or cut them with a knife. Hon. Edgar Wilson suggested to me that, as the larvæ used parts of the band and bark with which to build its cocoon poisoning the band might be an easy way of getting rid of many. I tried soaking the cloth bands in strong solution of paris green, but the results do not warrant any definite statement. I believe that this may kill some of the last spinning up, but doubt its efficiency of the earliest broods. However, it is worthy of further investigation. In want of better knowledge many people apply bands and do not kill the worms that have collected. In this way the insect is positively aided. Professor Gillette records a fact that must be noted. He finds that in the spring the larvæ leave their old cocoons and migrate to other places and spin new ones. This, however, is not always the case, but it should be guarded against. Bands should be applied about two weeks after the blossoms have fallen and be kept on for a week or so after all the fruit has been picked in the orchard.

Banding should always be practiced in connection with spraying, and by this combination the best results are obtained.

By spraying with Paris green and London purple and by banding, Mr. Tiner, of Boise, saved about 80 per cent of his apples. This orchard is in the city of Boise and has neglected orchards all around it.

Hon. Edgar Wilson used arsenites and banding. In the part of the orchard not infested by the moths from the apple house the loss is estimated from 5 to 10 per cent. In Mr. Fremont Wood's orchard the results were about the same.

Dr. Ustick, of Boise, used lime arsenite and banding. I estimated his loss to be about 10 per cent. I visited these last three orchards September 24, and searching diligently under the bands for larvæ, found but 3 under 30 or 40 bands. Mr. C. Hinze, of Payette, used Paris green with either kerosene or coal tar. He writes me that his total loss from all causes amounted to only 0.05 per cent.

For contrast it might be mentioned that in Mr. Tiner's orchard I found only 8 larvæ under bands at 18 trees, while in a neglected orchard on the same date (September 21) I found 94 larvæ on 10 trees.

In all these cases cited the orchards were sprayed from four to six times.

The pupæ may be killed with the larvæ under the bands by crushing. They are so well protected that this is the only practicable way to reach them.

I have previously stated how the adults in a storehouse may be killed. A few fruit growers have told me that they caught numerous adult codling moths by trap lanterns. All accurate work upon this point has shown that the moth is not attracted to light, the noctuids and sphingids caught being mistaken for codling moths.

One grower says he catches many of the moths in buckets in which there is some cider or vinegar. This fruit grower is a man well informed upon the subject and I tried to experiment with his remedy, but was stopped by cold weather and sickness.

SUMMARY AND CONCLUSIONS.

1. The codling moth is more injurious in Idaho than in the East, on account of the number and the overlapping of broods.
2. There are three broods and probably a part of a fourth, which overlap.
3. The moth can not be controlled by natural means.
4. It has been allowed to get a firm foothold in the State.
5. By several sprayings with arsenites and by banding the injury may be reduced to from 5 to 20 per cent, depending upon locality.
6. I firmly believe that if the recommendations given here be followed by all fruit growers in a locality for one or two years that the moth would cease to be a serious pest in that locality.

I recommend that this work be carried on in Idaho and possibly Oregon and Washington another year, as I believe this last summer's work has simply outlined the problem and discovered the points to be worked upon.

INSECTS AND THE WEATHER DURING THE SEASON OF 1900.

By F. H. Chittenden.

Investigations begun during the season of 1899 upon the effects of atmospheric and other conditions, in causing an increase or decrease of injurious insects during that year, were continued during the season of 1900 with some interesting results.

The studies of this subject that have been made have not been as complete as could be desired, but as a result of observations conducted

during the two seasons the writer feels justified in drawing some general conclusions. Some of these were given expression in an earlier article on pages 51–64 of Bulletin No. 22 of the present series.

It may be remembered that the writer hazarded an opinion as to the probabilities that certain Northern forms would continue in similar or increasing numbers as a result of protracted cool winter weather, that would tend to facilitate perfect hibernation, while certain Southern species, which were apparently nearly exterminated in and near the District of Columbia as a consequence of the cold winter of 1899–1900, would continue absent from this neighborhood, or at least that the crops habitually attacked by them would not be materially affected during the season of 1900. This prediction has been partially verified. Such Northern species as came under observation as a result of their injurious abundance in 1899 continued to be injurious, as it was judged they would, but certain of the Southern forms became quite numerous. True, only one of these was abundant early in the season, but the remainder, although extremely rare during the early part of the year, became sufficiently numerous to attract rather general attention late in the season. Prominent among these were the cabbage Pionea, the single species which occurred here in numbers from early in the year; the cabbage looper, which was universally troublesome to late cabbage and other cruciferous crops, and the boll worm, also destructive to late crops, such as corn and tomatoes.

As to the cause of the early reappearance of the first-mentioned pest after such extreme scarcity, the only conclusion that can be reached is that this was due mainly, if not entirely, to the flight of the parent moths from the South either late in the season of 1899 or early in 1900, or at both times. It is to be regretted, however, that the mature insects were not detected at lights or in the field either in autumn or spring. The cabbage looper and boll worm owe their increase probably to the same cause as the Pionea.

It is now a matter of almost annual occurrence—and the season of 1900 was no exception—for the cotton worm, *Aletia argillacea*, to fly from the cotton fields thousands of miles north of their natural habitat, a phenomenon well known to collectors, who frequently take this insect at electric lights in the Northern States, and even in Canada, although their larvæ have not been detected north of the cotton belt. This is only one of many species which have the same habit, and the writer believes that the invasion of the territory about the District of Columbia and northward by the three species above mentioned has been made in the same way, the moths having flown northward, at intervals perhaps, during the season with winds which favored this flight, from localities farther south not affected to the same extent by the atmospheric conditions of the winter of 1898–99.

A circumstance which lends color to the above expressed hypothesis,

that the re-stocking of the District of Columbia and its vicinity with the apparently exhausted supply of Southern forms was due mainly to flights induced by favoring winds, consists in the observed fact that there was not a corresponding increase in the numbers of Southern insects of other orders, such as beetles and bugs, insects of feeble powers of flight as compared to moths. The harlequin cabbage bug is an example of the less active fliers, as this insect was only slightly more abundant than in the previous year, until very late in the season, when injury occurred in some few localities.

ATMOSPHERIC CONDITIONS DURING THE WINTER OF 1899 AND 1900 AND SUBSEQUENTLY.

The condition of the weather at different periods of the year was noted whenever it was thought that these conditions might affect insect life. Some of the more important phenomena should be mentioned as a preliminary to remarks that will be made upon the effects of these conditions in limiting the increase or decrease of the insects under observation.

No change worthy of mention which it was thought might affect insects injuriously was noted during the winter months of 1899.

December 24 the temperature reached a maximum of 53° F. during the afternoon, and at this time several species of insects were observed at work in addition to those which will later be mentioned as affecting crucifers. That night, however, there was a considerable fall in temperature, a little more than 10° lower than the average for the day before, the minimum reaching 24°.

During the next eleven days there was a considerable drop in the temperature, snow falling and the ground remaining frozen until January 6 or 7. At one time during this period the temperature descended to 9°. On the 5th the days began to become warmer, but the night temperatures continued quite low, as low as 15° on the date mentioned.

February 24, after a protracted rainy spell of several days' duration, the storm cleared, the sun came out, and the thermometer reached a maximum in the afternoon of 58° F. Search among grasses showed several forms of insects in activity near the surface, and it is probable that many other insects were brought to the surface from their hibernating quarters by these conditions. That night a severe windstorm with rain and snow came on, the temperature dropping by 6 a. m. of the following day to 9° F., remaining below the freezing point for three days, but again attaining a maximum on March 1, of 59°, similar to that experienced after the storm just specified. For the next twelve days the temperature was scarcely below the freezing point for more than a degree or two at any time until March 11, when

another storm set in, the temperature falling to 11° F. the following day, but warming the day after that.

March 15 a storm set in about 6 a. m. with considerable snow fall, most of which remained upon the grass for five or six days, and in protected localities as late as the 24th. March 25 still another storm occurred, during the night, with a lighter fall of snow, followed by finer and clearer weather beginning on the 27th.

After the first of April winter weather had ceased and spring begun.

It would be a matter of some difficulty to define the exact significance to be attached to the terms Northern forms and Southern forms used in the present and also the earlier article of the writer on the subject under discussion. This matter can be best explained, perhaps, by repeating what has been said in the first article mentioned (p. 53), that the District of Columbia occupies a place, zoologically speaking, in the Carolinian faunal area nearly midway between its two extremes as at present defined: and the Northern forms are those which develop more freely north of this line, while the Southern attain their greatest increase south of this line. To be more explicit, however, it should be said that the injurious species which will be particularly mentioned as Southern are believed to be truly Austro-riparian, while the Northern species belong rightfully to the Alleghanian area of the Transition zone and the most northern portions of the Carolinian or upper Austral life zone. At least two species which it was found impossible to assign to either the Northern or Southern group, the writer believes, as a result of his study during the past season, have now been correctly placed. They are the fall army worm, which must be considered a Southern form, although it finds its way quite far northward, and the destructive green pea louse, which rightfully belongs in the Northern group.

OCCURRENCE OF SOUTHERN FORMS OF INJURIOUS SPECIES IN 1900.

Of the fifteen injurious forms of insects mentioned by the writer (loc. cit., pp. 55, 56) as unusually scarce in the neighborhood of Washington in 1899 several species showed marked increase. To mention these all in the same category, the list includes four species which were not seen at all the previous year. These are the pickle worm, *Margaronia nitidalis*, and the melon caterpillar, *M. hyalinata*, each of which was abundant in one locality only; the cabbage pionea, *Pionea rimosalis*, which was everywhere numerous and quite destructive throughout the season, and the garden webworm, *Loxostege similalis*, which was several times observed during September.

The Northern leaf-footed plant-bug, *Leptoglossus oppositus*, was generally abundant and was very troublesome, something never before noticed in this vicinity.

The horned squash bug, *Anasa armigera*, was similarly abundant, and so numerous in individuals on many plants examined that they often outnumbered the common squash bug, *A. tristis*, ten to one.

The corn-ear worm, *Heliothis armiger*, was moderately destructive early in the season, and appeared later in great numbers, and in some places did considerable injury to late corn, tomatoes, and similar crops which it is known to affect.

The cabbage looper, *Plusia brassicæ*, returned to this vicinity, and although rare early in the season, became quite troublesome to late cabbage. It seems probable that it is held in check, at least partially, in ordinary seasons by parasites and other natural agencies than weather.

It was not expected that the harlequin cabbage bug, *Murgantia histrionica*, would increase to any observable extent, and this was borne out by the season's observations, the species as a whole hardly ranking as an injurious one to crucifers other than horse-radish and very late cabbage. To horse-radish it was troublesome chiefly owing to the fact that drought also affected this plant, the crops suffering from the combined effects of the two factors.

One genius of Noctuidæ classed with the cutworms and of omnivorous tendencies, Prodenia, was noticeably rare in 1899, but the fact was not mentioned in the writer's consideration of the Southern forms affected by the severely cold weather of the preceding winter. Two species were very abundant during 1897 and 1898, the moths being commonly found at lights, but in 1899 they were extremely rare. In 1900, however, one form, *Prodenia ornithogalli* (*lineatella*) was frequently observed in the larval state in the field and more abundant on tomatoes than other crops, while the moths were not rare at lights. The other species, *P. commelinæ*, could not be found.

The Southern cabbage butterfly, *Pieris protodice*, which was scarcely seen at all, except in the mature condition in a few individuals during 1899, was found to have accumulated in great numbers at St. Elmo, Va., in the late fall. Mr. Pratt, who reported the occurrence, stated that next after the cabbage looper this was the most abundant enemy of crucifers in this region, occurring in about equal numbers on kale and turnips from the latter days of September throughout the month of October.

The Southern tobacco worm, *Protoparce carolina*, also increased in great numbers, particularly during the latter part of the season, and was destructive to late growing tomato plants. The Northern tobacco worm, or tomato worm, *P. celeus*, it should be remarked, was rare as in the previous year. The parasites of both of these, as usual, were very abundant.

The fall army worm, *Laphygma frugiperda*, although it extends its distribution quite far north at times must be included in the category

of Southern species, as it is of comparatively recent Southern origin and appears to die out from year to year in its more northern range. It was destructive in a single locality, the District of Columbia, late in the season, but was not reported by any of our numerous correspondents in spite of our inquiry.

Of other Southern forms the green June beetle, *Allorhina nitida;* imbricated-snout beetle, *Epicærus imbricatus;* squash-vine borer, *Melittia satyriniformis*, and American locust, *Schistocerca americana*, showed a perceptible increase in numbers, while the tobacco flea-beetle, *Epitrix parvula* was not so abundant. The larger corn stalk-borer, *Diatræa saccharalis*, was not seen at all.

The opportunity is taken to observe that the eggplant flea-beetle, *Epitrix fuscula*, a Southern form, was extremely abundant during the year, but flea-beetles, as the writer has had occasion to observe in his earlier article, seem to be little affected by changes in weather.

In earlier mention of the weather in relation to the destructive green pea louse, *Nectarophora destructor*, and its abundance during 1899, the writer was unable to specify as to whether it belonged to the northern or southern group of injurious insects. It would now seem that it is a northern species, as it is recorded from several Transition localities, notably in Wisconsin and in Nova Scotia and other portions of Canada, where it is destructive, and, so far as reports go, it has not found its way farther south than a northern strip of the lower austral in southeastern Virginia, near the seacoast, and a single known locality in North Carolina. It therefore falls naturally into the list of species that have multiplied in the neighborhood of the District of Columbia as a result of the cold winters experienced during two years. Nothing else can explain its great abundance, as none of its natural enemies, if we except the fungous disease to which it is subject and which has not yet been made the subject of special study by anyone, either in its relation to the multiplication of this insect or otherwise, have had any appreciable effect in reducing the numbers of this pest.

Taking into consideration the occurrence of this species throughout the country, it would appear that it was at least as numerous in 1900 as in 1899, as during the latter season it was destructive over the same and additional area, although not in all cases to the same extent as in 1899. Its increase westward was noticeable.

ABUNDANT NORTHERN FORMS IN 1900.

Of the northern forms of insects which were present in great numbers in 1899 nearly all of the thirteen species mentioned (loc. cit., pp. 56, 57) occurred in the same numbers during 1900. There were severe outbreaks of the oblique-banded leaf-roller, *Cacœcia rosaceana*, not only about Washington, but in various other portions of the country

and as far south as Norfolk, Va., and the strawberry leaf-roller, *Phoxopteris comptana*, was extremely abundant here, in Maryland, and elsewhere. Three of the species previously mentioned, however—the rhubarb curculio, zebra caterpillar, and plum moth—were not conspicuous by their numbers.

The raspberry sawfly, *Monophadnus rubi*, was more abundant than in the previous year.

The asparagus beetles, *Crioceris asparagi* and *C. 12-punctata*, were reported by Professor Johnson to have occasioned some injury in Maryland (Bul. 26, p. 81), but the hot spell of July and August practically put a stop to injury, as neither beetles nor larvæ of either species were to be found in late August and early September, when the plants in several localities were examined.

ON SPECIES COMMON TO NORTH AND SOUTH.

It may be well to state briefly that of the seven species previously noticed (loc. cit., pp. 57, 58) as having been particularly destructive about Washington in 1899, and which do not fall into either category of north or south as to origin, all were destructive during 1900, although in some instances in restricted localities.

The bean leaf-beetle, *Cerotoma trifurcata*, did more harm in the East than was ever before known. The same is true of the spinach flea-beetle, *Disonycha xanthomelæna*.

One of the most interesting of injurious occurrences of the year was that of the variegated cutworm *Peridroma saucia*, which was quite destructive over a wide extent of country, including the Pacific coast, where it was particularly troublesome in the State of Washington. The infested territory comprised portions of Texas, Missouri, Kansas, Maryland, West Virginia, Illinois, Washington, Oregon, and northern California, and the crops infested included nearly everything that grows in gardens, as well as the foliage and fruit of various orchard trees. According to testimony of some of our correspondents, this insect assumed the habit of traveling in armies, but was not noticed on the march in the daytime.

ON NATURAL ENEMIES AND THEIR INFLUENCE UPON INSECT REPRODUCTION.

The question of the effects of the abundance of natural enemies upon injurious insects is closely related to the effects of weather upon them, but the subject is much involved, and we know so little about it that it is difficult to generalize with much certainty. This much is certain, however, that conditions which would affect injuriously a parasite may not necessarily affect a host; predaceous insects are not necessarily affected by conditions which would be injurious to either

parasitic or to injurious species, while fungous and bacterial diseases are probably affected by still different conditions.

Predaceous insects, as a rule, are more resistant to extremes of temperature, dryness, or humidity than all of the other insects and organisms which produce diseased conditions of insects.

Parasitic insects were more abundant during the season of 1900 than during 1899, but this does not apply to all of the common species. For example, our two common parasites of the imported cabbage butterfly, though numerous early in the season, were extremely rare toward the close of the year.

Some experiments were made to test the prevalence of parasitic insects and fungi and their effects upon the reproduction of some common pests.

The imported cabbage butterfly, *Pieris rapæ*, was one of the species with which experiments were made. Larvæ were obtained from all available sources from the District of Columbia, Virginia, and Maryland, and kept under the best possible conditions during September, 1900, with the result that not a single parasite was reared, nor did this species appear to be affected by any disease at this time. Practically all of the larvæ used in experiments which were approaching maturity when placed in our rearing jars produced pupæ and eventually butterflies.

While on the subject of the parasites and other natural enemies of this cabbage pest it should be stated that *Pteromalus puparum* and *Apanteles glomeratus* made their appearance with the development of the first generation of butterflies, the Chalcidid appearing at the same time and the Braconid only a few days later. The wheel bug, *Prionidus cristatus*, does not appear to have been recorded as an enemy of this cabbage worm. It was many times observed during the season of 1900 devouring the "worms." One was observed June 23 which had killed a larva twice its size.

Specimens of diseased larvæ referred to the Division of Vegetable Physiology and Pathology in the fall of 1899 were found to be affected by a fungus of the genus Sporotrichum, identified by Mrs. Flora W. Patterson as probably *S. globuliferum* Speg.

The cabbage looper, *Plusia brassicæ*.—Diseased and dead larvæ of this species taken in the fall of 1899 and referred to Mrs. Flora W. Patterson, Assistant Pathologist, were identified as suffering from a fungus of the genus Entomophthora, doubtfully referred to *sphærosperma* Fres., a species which occurs upon many insects of different orders.

During September, 1900, it was estimated that a little less than 20 per cent of the larvæ of this species present in the fields about the District of Columbia had yielded to the effects of disease usually just before attaining maturity. This disease was by no means general, and

was found to be more prevalent in Maryland near the District line than on the grounds of the Department of Agriculture. In the latter place there was practically no infection worth mentioning.

A very large proportion of cabbage loopers was affected by the minute parasite *Copidosoma truncatella*, perhaps 15 per cent during September, but none in earlier and less in later months.

Observing that the larvæ were most extensively affected by the Copidosoma parasite in a region badly infected with rot, a number of healthy larvæ were placed on potted cabbage affected with both the bacterial and brown rots, while others were kept as a check lot on fresh cabbage, this experiment being made to ascertain if the rots were in any way responsible for the diseased condition of larvæ. Somewhat to the writer's surprise it could not be seen that the larvæ placed with the diseased plants were affected in any manner more than those kept under the same conditions with perfectly healthy plants.

The melon plant-louse, *Aphis gossypii* Glov., affords a striking example of the combined effects of weather and natural enemies in the control of an insect. Of all common plant-lice this species appears to be most susceptible to climatic variations. During moist or humid weather, particularly in the early portion of the summer, this species is capable of propagating in the greatest numbers, but during protracted heated and dry spells, such as happened in the season of 1900, its natural enemies, which are legion, are able to keep it almost completely under control. During the year it was not reported at this office as doing any damage save in one locality in Nebraska, a State in which it does as much if not more damage than any other in our country. In the year 1899 this species was very destructive in the States of Florida, Texas, Maryland, Virginia, Pennsylvania and Georgia, and District of Columbia, while the previous year it did damage over much the same territory, as well as in Kansas and Arkansas, injury being particularly pronounced in Texas.

SOME GENERALIZATIONS.

As a result of study of the subject of the effects of weather upon different species of injurious insects which occur in the neighborhood of the District of Columbia during the past year in connection with observations that were made the previous year the writer has deduced certain conclusions. One of these, not expressed in the earlier article on this subject, is that there is a tendency on the part of introduced forms to develop one or more generations in their adopted habitat than native northern species produce, a habit which conduces very largely to their destruction, resulting in a corresponding decrease in their numbers.

TENDENCY OF INTRODUCED FORMS TO PRODUCE EXTRA GENERATIONS IN ADOPTED NORTHERN HABITATS.

European introductions in the United States frequently produce one or more generations in excess of the number that has been observed and recorded in the northern countries of Europe where observations have been made, and even attempt generations late in the year, which are often apt to perish by being overtaken by frosts before transformation can be accomplished or suitable places sought out for hibernation.

Southern forms that migrate northward in time appear to become perfectly at home in northern localities; in fact, thoroughly acclimated, but this is apparent only, as there is every reason to believe that many species attempt the production of one or more generations more than similar northern species have; or, in other words, essay the normal generations which they had in the south, which are apt to be cut short by intervening cold weather before their completion.

Examples of both forms are apparently more frequent in leaf-feeding mandibulates, particularly the larvæ of Heterocera or moths and phytophagous Coleoptera, especially Chrysomelidæ or leaf-bettles. Several injurious forms of plant-lice are in the same category, although these have not been given special study. Many genera are known to feed in cold weather long after frosts, and may even be taken on their host plants under the snow.

An excellent illustration of polygnéutism, or the production of several generations annually in a species recorded as normally monogneutic in its native home, is to be found in the imported elm leaf-beetle, *Galerucella luteola*. There can be little doubt that this species is monogneutic in Europe, but observations conducted at New Brunswick, N. J., and Connecticut cities in the Upper Austral life area have shown that there is an incomplete second generation. In the more southern portions of the same life area there are invariably two generations annually, and in exceptional seasons a third generation is attempted; at least, beetles of the second generation have been observed to lay eggs.[1]

An example of an extra generation being produced by a southern species is found in the squash-vine borer, *Melittia satyriniformis*, which is single-brooded on Long Island and northward, apparently single and partially double-brooded in New Jersey, while in the latitude of the District of Columbia the species is both single- and double-brooded, as shown by the writer in recent years (Bul. No. 19, n. s. Div. Ent., p. 39). This peculiarity in reproduction is evidently a survival of the time when this species lived in a tropical climate, where it was

[1] Even some of our native species closely allied to the elm leaf-beetle, e. g., *Galerucella americana* Fab., have been observed by the writer to lay eggs for a second generation late in July (Proc. Ent. Soc. Wash., Vol. III, p. 275), but this is, with little doubt, exceptional.

possible for breeding to be more nearly continuous. The instinct of this and other insects of recent southern origin is still to remain late feeding in the open, provided appropriate plants are available for their subsistence, or, to put it otherwise, they have not learned to seek shelter at the same time as native or acclimated forms do.

Recent observations on this and other species of similar habits and origin suggest that the ancestors of those individuals which produce only a single generation were introduced in early times and are thoroughly established and acclimated, while those which produce a second generation are the offspring of ancestors which have spread from the south more recently and have not yet become accustomed to the differences in the weather in the North and in the South.

The development of two generations by Melittia and other southern introductions in the District of Columbia and places having a similar climate is a matter apparently not so much dependent on the weather as upon the inability of the insects to find the appropriate food for their larvæ; for example, were cucurbits to be planted earlier and later, there would be no trouble in the vine borer producing two well-marked generations in spite of the fact that the vines of cucurbits are readily killed by frosts, the insect being able to survive upon stems which are not of the freshest.

Certain species recently observed, e. g., *Plutella cruciferarum*, the diamond-back cabbage moth, there are the best of reasons for believing are able to produce an additional generation during the latter days of November and the first week of December, as many larvæ captured at this time were full grown and accompanied by numerous pupæ, most of the individuals captured changing to pupæ before the end of the first week of December, in which condition they would naturally be less exposed to frost and better able to survive the rigors of winter. Still another generation, however, was attempted, as one moth captured deposited its eggs at this time. This generation was, of course, doomed to failure.

The effort on the part of so many introduced Old World species of producing extra generations would naturally lead to the belief that these insects came originally and in comparatively recent times from southern Europe or southern Asia, became acclimated farther north in Europe in the same manner that native Southern forms become established by migration to our Northern States, whence they were introduced in the Upper Austral portions of the United States, for the most part about our principal seaports, Boston, New York, and in some cases Baltimore, and in other large cities, such as Philadelphia and perhaps Washington, and after becoming adapted, more or less imperfectly perhaps, to the environment of those cities, have made their way still farther south, where they have again resumed what was probably their original habit of producing two, three, or more annual generations.

RESIDENCE OF CERTAIN SOUTHERN FORMS IN LOCALITIES FAR NORTH OF THEIR NATURAL LIMITS IS TRANSIENT.

In the increase of the areas occupied by these insects they obey a natural impulse for migration, and are evidently largely influenced by the wind, and this is particularly the case with moths. There can be little doubt, also, that insects introduced into the North, and from there southward, are again brought northward by winds from the South; in fact, there is little stability in the localities occupied by many species, winds, frosts, prolonged heat and consequent drought, excessive rains inducing abnormal moisture of the insect's food plants, diseases, and natural enemies being among the elements which produce changes causing fluctuation in numbers in this or that locality, a decrease here this year and an increase there another year.[1]

SPECIES INTRODUCED IN THE NORTH FROM THE SOUTH AND FROM EUROPE REMAIN LATE IN THE FIELD.

Southern or Lower Austral species, particularly those which are injurious, which have come up to this region from the South in comparatively recent years, are rarely found early in the season, especially after severe winters, but increase toward the end of the season, and often, if not usually, occur in their larval stages, busily feeding through the months of October and November, even after frosts, as has been noticed for several years, and particularly during the two seasons just passed. The same is true, for some reason, of species which have widened their range in other directions, and particularly of insects which have been introduced from Europe.

Most of the introduced plant-lice, and those which have come up from the South, live on their food plants after frosts, long after nearly all other insects have disappeared in the field.

It is true that many native plant-lice also remain feeding late in the season.

[1] The writer desires here to call attention to the absurdity of recording strong-flying species of insects, and especially moths, like those just mentioned, as residents of northern localities beyond their natural limits, where there is no proof whatever that the species could ever have bred there, particularly when we know that no food plant upon which the larva could have subsisted grows there. If such species are included in local lists at all, the circumstances attending capture should be added. A familiar example of an insect which lives normally in the South and is frequently found as far northward as Canada is the gigantic Noctuid, *Erebus odora*. It is native to the West Indies, and not known to breed in the United States. In spite of recent remarks that have been made that would appear to indicate that this moth might breed within the territory of the United States proper, the writer can not believe that it is at present established here, or even will be within the near future, as only isolated specimens are found northward, and these in late summer or autumn, as in the case of the cotton-worm moth, which it has been, I think, definitely proved does not breed in the Northern States.

Of southern species both the cotton worm and the boll worm moths are to be found very late in the season, and the writer has seen the cotton-worm moths in November in great numbers at Ithaca, N. Y., at light, after most other insects had been absent from lights, at least in any numbers, for weeks. Immense numbers of the moths were attracted to the electric lights on the principal streets of the city.[1]

Larvæ of two important species, the imported cabbage butterfly, *Pieris rapæ* and the diamond-back moth, *Plutella cruciferarum*, both of comparatively recent introduction, were found during the winter of 1899–1900 in the last week of November freely feeding after several frosts. They were accompanied by the harlequin cabbage bug, *Murgantia histrionica*, which we know to have recently spread northward from the Southern States, and by the cabbage looper, *Plusia brassicæ*, which has also spread from the south northward, though not in very recent times.

SUMMARY OF CONCLUSIONS.

The result of recent studies may be summarized briefly as follows:

(1) That there is a tendency on the part of forms introduced in the North from farther South to produce one or more generations in excess of the number developed by similar forms native to the region of this adopted habitat.

(2) That as a result these forms remain later in the field than do species native to the North.

(3) That, largely as a result of the above and other habits, in addition to greater susceptibility to low temperatures, these southern introductions are apt to be destroyed every year in large numbers, their residence in their northern homes being, therefore, not strictly permanent. Cold snaps following warm spells during the winter are, according to observation, the most important factors in their destruction.

ON THE HABITS OF ENTILIA SINUATA.

By L. O. Howard.

This interesting little leaf-hopper, certain of the habits of which have been described by Mrs. M. E. Rice, of Coryville, Pa., in Volume V of Insect Life (pp. 243–245), is common throughout the eastern United States, and may be found upon many different plants, such as potato, ragweed (Ambrosia), spikenard (Aralia), *Cnicus altissimus*, *Lactuca spicata*, *Rudbeckia laciniata*, cotton, sunflower, and other annual and herbaceous forms. Mrs. Rice studied the eggs, which were laid upon the midrib of a leaf of sunflower and began to hatch

[1] The exact date was not noted, but it is much colder in that locality than on the corresponding date in Washington, there being about a month's difference in that climate in ordinary seasons, and although the event happened many years ago, it is remembered that a heavy overcoat worn at the time was very comfortable.

out on September 1. Sunflower leaves infested by the larvæ die and the whole plant looks as if scorched. About two weeks after hatching the larvæ molt for the first time. During their entire life, Mrs. Rice noticed, almost every colony was guarded by one or more ants. When she raised the leaf to examine closer the ants gave battle and bit her finger. When she removed the ants the little leaf-hoppers, both larvæ and imagoes, scattered with astonishing celerity all over the plant. The ants returned and rounded them up exactly as the collie dog does sheep, placing one ant on guard if the colony were small and more if the colony were large. She noticed when one of the little leaf-hoppers strayed away an ant went after it and, with infinite patience, drove it home again. She noticed further that when

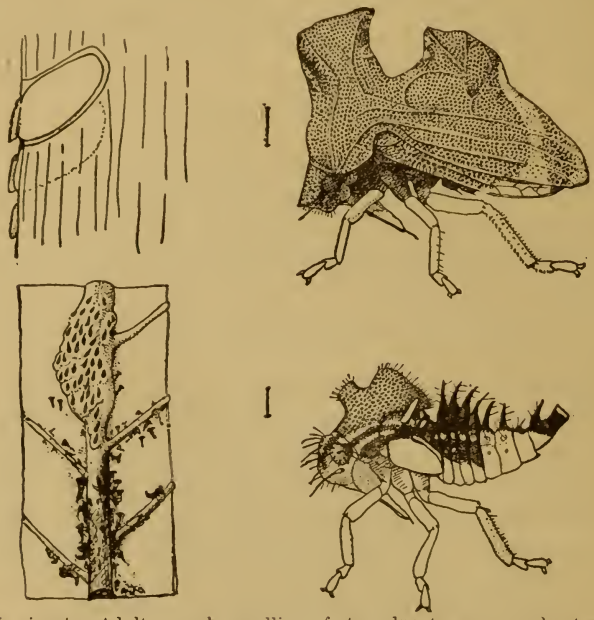

FIG. 27.—*Entilia sinuata:* Adult nymph; swelling of stem due to eggs; angle at which eggs are laid (original).

the larvæ were ready to molt and the skin began to split on the back the ants supervised the process, seeming to peel off the empty larval skin. When one considers the fact that the leaf-hoppers in perfect condition can both fly and jump, the control which the ants maintain over them is remarkable. The writer had an opportunity of studying this interesting little insect during the month of August near Tannersville, N. Y., also upon sunflower, and from the specimens collected at that time the accompanying illustrations have been drawn.

The swelling of the midrib, caused by the insertion of the eggs, was very pronounced, as shown at figure 27, while the exact angle at which the eggs are inserted is also shown at figure 27.

The young, when first hatched, were almost immediately attended by two species of ants, specimens of which were collected, and which are determined by Mr. Theodore Pergande as *Camponotus pictus* Forel. and *Formica subsericea* Say. It was noticed, however, that both species of ants were not found upon the same leaf. Specimens of one species would guard a colony upon one leaf, while on the next leaf on the same plant a colony of the leaf-hoppers might be guarded by several specimens of the other species of ant.

When so guarded the leaf-hoppers clustered at first near the midrib and in the vicinity of the eggs in the manner shown at fig. 27. The successive stages of development are shown at figs. 28 and 27. The second and third larval stages are very characteristic, and not until the final larval stage is reached does the young show any resemblance to the adult leaf-hopper.

A curious and interesting observation was made upon the first egg

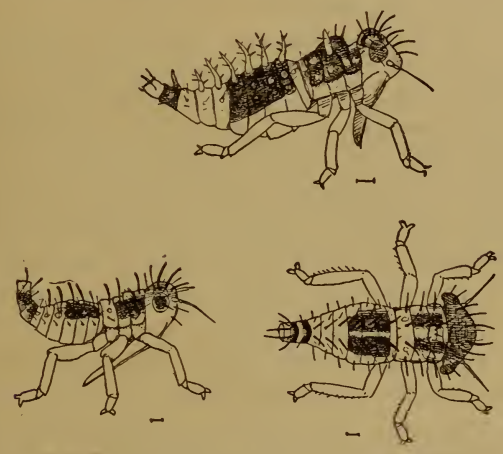

FIG. 28.—*Entilia sinuata:* Successive larval stages—enlarged (original).

mass seen, and which was verified again and again, and that is that the adult female seems to brood over her eggs until they are hatched. She assumes a position upon the swollen midrib parallel to the leaf surface, instead of perpendicular to it, and waits patiently and almost motionless for several days—in fact, until the young are hatched. The ants do not bother her while she is thus brooding. As soon as the young hatch out they put in an immediate appearance, and all of the observations made by Mrs. Rice mentioned above have been verified. Considerable honeydew is secreted by the larvæ, and this is undoubtedly the cause of the care taken by the ants. When allowed to stray the leaf-hoppers will run around to the upper side of the leaf, but are soon driven back by the ants and kept massed into clusters. The work of the insects causes the ultimate yellowing and dropping of the leaves, in which case the leaf-hoppers are carefully removed by the ants and placed upon fresh leaves. The Entilia may thus be considered an

injurious species to cultivated sunflowers, and as the ants encourage them, take good care of them, and place them upon fresh leaves, the ants themselves become thus indirect enemies to the plant.

A kerosene emulsion spray is of course a perfectly efficient remedy.

FUMIGATION WITH CARBON BISULPHIDE.

By W. E. Hinds.

U. S. Department of Agriculture,
Division of Entomology,
Washington, D. C., July 15, 1901.

Sir: I submit herewith a report upon the use of carbon bisulphide in the fumigation of a large wholesale and retail tobacco establishment in Washington, D. C., together with some details of caution in its use and a few observations concerning the effects of this insecticide upon the user, which I have not found published hitherto.

Respectfully,

W. E. Hinds.

Dr. L. O. Howard,
Chief of Division of Entomology.

On the 13th of July, in accordance with your instructions, I visited this establishment and made a general investigation. The business is confined to what is practically one large room, having about 3,000 square feet on the ground floor and a cubical content of about 75,000 feet. At a height of about 12 feet a wide gallery runs around three sides of the room. This gallery, as well as the main floor, is filled with tobacco of various grades and styles of manufacture and in all kinds of packages. Altogether the stock consisted approximately of 800,000 cigars, 400,000 cigarettes, and 37,000 pounds of smoking and chewing tobacco. Only a very small portion of the stock showed any signs of infestation, and this was stored partly in the gallery and partly on the main floor. Several kinds of high-grade smoking mixtures (obtained mostly, as the proprietor informed me, from the same factory) were being seriously damaged by the cigarette beetle, *Lasioderma serricorne* Fab. It was stated that the beetles seldom appeared till the stock was about two years old, and the proprietors believed that the eggs were in the tobacco when it was packed, but that they remained dormant for a year or so more, developing abundantly toward the end of the second year. This, of course, is not the case. However, it may be possible that some stock was infested at the factory and the beetles subsequently passed through several generations in the package before their presence was discovered, and it seems very probable, since the beetles have been quite abundant in the store for at least the past two years, that stock originally clean may have become infested in the store during the two years in which it was more or less exposed to infestation.

A large number of the beetles were noticed in the store last year, and a small portion of the stock was at that time treated with CS_2; but the fact that some of the old stock is now badly infested makes it appear very probable either that the first treatment was not sufficiently

extensive to include all the infested stock or that it was not thorough enough to destroy all the beetles in what was treated. This partial treatment was, however, sufficiently successful to satisfy the proprietors that if used in a sufficiently large quantity and so as to include the entire stock, carbon bisulphide would eradicate the pest. They had, therefore, made preparations to thoroughly fumigate the whole establishment, applying more than double the quantity of the insecticide that is usually recommended in such work. They desired to clean out the beetles at any cost and preferred to use an excessive amount of bisulphide rather than be obliged to repeat the treatment. Accordingly, they had provided 200 pounds of CS_2 and about 35 shallow tin pans about 3 feet long by 1 foot wide and 1 inch deep. At the writer's suggestion, an additional supply of evaporating pans was obtained. Over fifty of these large pans were distributed around the room in as high positions as possible, and a number were placed on top of the stock stored around the gallery. The stairway and elevator shaft leading to the basement were tightly closed and the worst infested stock was opened and the boxes spread around upon the lower floor. The cans of bisulphide were distributed and everything done to facilitate rapid work in the application of the liquid. Owing to the slight danger of generating a spark in turning off the incandescent lights which it would be necessary to have if the application were made at night, it was thought best to defer the exposure of the liquid till early on Sunday morning, July 14. (The dangers connected with the use of carbon bisulphide will be spoken of more fully at another place in this report.)

Soon after 6 o'clock on Sunday morning the work of pouring the bisulphide into the pans was begun simultaneously by the six persons (including the writer) present. Each pan received from 2 to 3 pounds of the liquid. The pans in a vault and the show window and in the wall show cases were filled first and the doors to those compartments were then closed to retard the fumes. Otherwise the doors to show cases and closets and the drawers were all left slightly ajar to allow the unhindered entrance of the fumes. The pans around the sides of the rooms under the gallery were placed so high that a 5 or 6 foot stepladder had to be used to reach most of them. As only one such ladder was at hand, the work was somewhat delayed at this point, and all lower pans on goods along the middle of the floor and on show cases were filled before the work on the higher pans could be completed. In the meantime the pans in the gallery were being filled and the fumes on the lower floor were becoming very dense. The air supply had become insufficient for the workers, and instructions were given to each man to go outdoors as soon as he began to feel dizzy. This most of them did, and after a few refreshing breaths they were able to return to the work; but one or two did not leave the room until the work was finished. (The effects of the gas upon the operator will be

considered more in detail at another point.) After about 145 pounds of CS_2 had been exposed, occupying from fifteen to twenty minutes, the fumes had become so dense that we were forced to withdraw. The building was then carefully locked and left for twenty-two hours. People passing on the street at the time the exposure was being made and those having business in adjoining rooms complained of the exceedingly disagreeable odor, but at a visit to the premises later in the day the writer could detect but very slight traces of the odor on the street, even close to the door. No guard remained near the building during the day.

On Monday morning, at 4.45, the store was opened for ventilation. The density of the fumes had greatly diminished, but a watch was kept to see that no one passed close to the door with a lighted cigar until the fumes had mostly disappeared. In forty-five minutes the store was so well aired that but little of the disagreeable odor remained, though for several days slight traces of the odor lingered in the room.

An examination of many boxes of the infested stock on the lower floor disclosed many dead beetles, but no living ones. Unopened boxes of stock in the gallery were examined, and these showed only about one live beetle to every one hundred dead ones. So far as could be determined at the time, the treatment was very successful, and the proprietor expressed himself as very well pleased with the result.

The suggestion was made that future trouble with the cigarette beetle might probably be avoided by treating incoming stock with CS_2 in a quarantine chamber before placing it in the sales room. In the basement the writer was shown a large, zinc-lined, air-tight box, having 18 cubic feet capacity, which has been used as a moistening chamber. Upon being assured that this was an admirable thing for a quarantine box, the proprietor declared it his purpose to adopt the suggestion and treat all new or suspected old stock in this way.

DANGERS IN USE OF CARBON BISULPHIDE.

It is customary when anything is written concerning the use of this very volatile and highly inflammable liquid to emphasize the danger from fire in the presence of the fumes, and it is usually pointed out particularly that even a lighted cigar may cause a disastrous explosion. The writer has also seen printed mention of the danger of liberating the fumes in the presence of heated steam pipes. So it seems that a brief mention of a few other points of danger may not be out of place here.

No electric fan should be allowed to run in the presence of the fumes, as it is liable to give off occasional sparks. For the same reason there would be danger in turning on an incandescent light, and though the danger in turning out such a light is less than in turning it on, there is still too much chance of forming some connection which would pro-

duce a spark to run the risk of the explosion which would almost surely follow. The writer has personally experienced the formation of such a spark when turning off a light, and it very frequently occurs when turning it on. The danger from gas and arc lights is too apparent to need more than mention. It would be a matter of courtesy as well as a measure of safety to inform occupants of adjoining rooms of the nature of the work being done and the need for care in regard to fire should the fumes find entrance to their establishments. An additional safeguard would be to station a watchman on the premises till the treatment is ended. The danger to the operator making the exposure is but slight if he knows the nature and effects of the gas. As soon as he finds that he is being overcome and getting dizzy, he should at once get out into the open air.

EFFECTS OF THE GAS UPON THE OPERATOR.

The first appreciable effect is upon the sense of smell. At first the fumes have an extremely disagreeable odor; but the odor soon seems to gradually disappear, and in this treatment the men strongly doubted that they were using the same substance with which they began. This deadening of the smell continues until it is complete. The other senses seem to become benumbed simultaneously, so that the operator does not feel or realize that any change is taking place in him. But the heart beat becomes more and more rapid as the supply of oxygen in the lungs diminishes. The power of thought is very much weakened and the work is continued in a mechanical sort of way. Hearing and sight are also weakened; in fact, consciousness itself is being gradually lost. But before this weakening process has gone far enough to be really dangerous or injurious the operator feels rather "queer" in the head, with more or less dizziness. There is no pain or disagreeable sensation, no desire to escape out of it, and no sense of suffocation. But when a person reaches this condition it is high time to get out into the open air, where the ill effects will soon disappear. Should the operator persist in remaining longer in the room after this condition is reached there would be danger of a fall; and if no one happened to be near, his presence might not be missed and suffocation would soon follow. Even if he should get out safely the after effects would be more serious and a severe headache, at least, result. It should be clearly understood, however, that the action of the gas is somewhat poisoning as well as suffocating. These observations concerning the effects of the gas upon the men are gathered from personal experience and the statements of others engaged in making the treatment herein reported.

Owing to the effect of the gas upon the action of the heart, the writer believes that it would be wise to caution persons having any

trouble or weakness about the heart against taking any part in the application of carbon bisulphide.

In view of the increasing use of CS_2 as an insecticide and the scattered condition of such observations as have been published in regard to it, the writer respectfully suggests the desirability of a more comprehensive report than has yet been made, published in some such form as to be readily available to all those desiring practical information upon this subject.

GENERAL NOTES.

ICHNEUMONID PARASITES OF THE SUGAR-CANE BORERS IN THE ISLAND OF REUNION.

Under this title M. Edmond Bordage, director of the Museum of Natural History of Reunion, has published a brief account of *Ophion mauritii* Saussure and of *O. antankarus* Saussure, which are parasitic in Reunion on the larvæ of *Diatræa striatalis* and *Sesamia albiciliata*, two destructive sugar-cane borers of that island and of Mauritius. He thinks that they are responsible for the marked reduction in the numbers of the borers.

The accompanying figures are from drawings by M. Bordage, and illustrate the wing venation of *O. antankarus*.

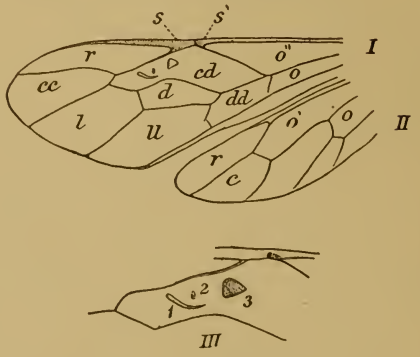

FIG. 29.—Wings of *Ophion antankarus*—I, upper wing; II, lower wing. The large cell (*cd*) of the upper wing has three spots of reddish or yellowish color, which are given in detail much enlarged in Fig. III; they take the form of a crescent, a mere speck, and a triangle. (With *O. mauritii* there is found in the interior of the large cell (*cd*) only one spot which is formed like a triangle.)

INSECTS FROM BRITISH HONDURAS.

The Rev. W. A. Stanton, S. J., of St. Louis University, St. Louis, Mo., sent February 12, 1900, for identification certain insects collected at Belize, British Honduras. The notes which accompanied them are of interest.

An insect known locally as the "doctor fly" was identified as *Diachlorus ferrugatus* Fabr. Mr. Stanton writes:

> The fearful local swelling which follows the bite of these insects causes them to be regarded with dread by the inhabitants. The effect, however, varies in different individuals.

Some small flies, very troublesome in some quarters, and called by the natives "botlass" flies, were determined as a species of Simulium; unfortunately, the specimens were too badly injured for study. The bite of this insect is quite painful and leaves a black spot on the skin, surrounded by a reddish circle which lasts for a week or more.

A species of tick taken from the body of one of the deadly "tommygoff" snakes, a species of Lachesis or "bushmaster," quite common in Belize, was identified as belonging to a species of Ophiodes.

Three spiders were sent and identified as *Argyroepeira argyra* Walck., *Argiope argentata* Fab., and *Gasteracantha cancriformis* Linn. The dorsal surface of the abdomen of the last named when alive is brick red in color, though many individuals are found, seeming to an ordinary observer to be of the same species, in which the color is pure white, or sometimes lemon yellow.

The sending also included specimens of the white ant, *Termes* sp. (probably *morio*), and a small black ant, very common in Belize, known scientifically as *Cryptocerus alfaroi* Em. ♀

NOTES FROM THE PHILIPPINES.

Lieut. Alfred T. Clifton wrote this office April 20, 1900, from military station No. 5, Bacolod, Negros, Philippine Islands, transmitting some specimens, with interesting notes. A giant wasp which he sends he states is called in the Philippines "avisar," or take notice, a sufficiently suggestive name for an insect of its class.

At the time of writing grasshoppers were very destructive, ruining the sugar crop in a few hours wherever they stopped. Our correspondent had seen great clouds of these creatures, so numerous that they obscured the sun, passing over the town. The natives on haciendos on such occasions turn out and beat on bamboo and make a racket to frighten them off.

The grasshoppers are very ravenous—always hungry. In the morning you can pass a field of young sugar cane a foot high, and when you return that way at noon it will sometimes look as if nothing had ever been planted. Notwithstanding this, these langosta, as they are termed by the inhabitants, are considered a great delicacy, but our correspondent had never had the courage to test this personally.

It is customary to place obstructions of sections of banana trees on top of the furrows of growing cane, and the locust eats the canes furrow by furrow, and when he reaches the obstruction, instead of going over it, he hops to the end where a hole has previously been dug, into which he falls. Here the locusts are collected and are then boiled, after removing the legs, heads, and wings. Thus prepared they make a black-looking mess. One haciendero stated to our correspondent that he had shipped a load of locusts to Iloilo, where they were worth $4 a bag.

The natives believe that the locusts come every seventh year.

Mr. F. F. Crevecœur, Onaga, Kans., an entomologist of considerable experience and a valued correspondent of this office, has reported the results of some interesting observations made by him during the past season (1900). Some of these are, in brief, as follows:

Notonecta undulata, one of the common, so-called back-swimmers, was observed feeding upon a related species, *Anisops platycnemis*, on one of our largest species of Corisa, and on the Dytiscid water beetle, *Coptotomus interrogatus*.

March 19 a species of spider, *Xysticus gulosus*, was noticed feeding on the dung beetle, *Aphodius inquietus*, under a board on the ground.

Crepidodera rufipes, the red-legged flea beetle, a long account of which was published some years ago in Volume V of Insect Life (pp. 341), was stated to be very abundant in the State of Kansas. It is a destructive enemy of young peach, cherry, and other fruit trees.

May 30 a wasp, *Odynerus tigris*, was observed bearing a larva and flying about a post in a barn looking for a hole in which to deposit it. The next day some of the same kind of larvæ, as well as pupæ, were found on the willow, *Salix amygdaloides*, which were reared and proved to be *Lina scripta*, the streaked cottonwood leaf-beetle.

June 6, *Anomœa laticlavia*, an interesting Chrysomelid, was reared from its pupal case found under a log about a month before. This case, which was made of dirt, was described as about five-eighths of an inch long by half that width, convex laterally, and somewhat concave longitudinally on the under side, with a fringe along the sides and crimped on the under side only, giving the case the appearance of being of organic origin instead of being of dirt.

June 18 *Plusia brassicæ*, the cabbage looper, was reared from larvæ on cottonwood, which pupated June 9. June 21 the same species issued from the larva taken on cottonwood, which pupated June 12. It will be noted that the pupal stage in both cases lasted nine days.

On two occasions during the latter days of June *Dasyllis tergissa*, a large robber fly, was noticed feeding upon *Macrobasis unicolor*, the ash-gray blister-beetle, *Onthophagus hecate*, a dung-beetle, and *Euschistus tristigmus*, a plant-bug.

June 10 *Atomosia puella* was noticed feeding upon *Lonchæa rufitarsus*, both Diptera.

June 14 *Macrobasis unicolor* was observed feeding on the bloom of hollyhock. It had ragged three or four flowers on this plant when observed.

While picking strawberries our correspondent happened to touch a specimen of the plant-bug *Euschistus variolarius*, which is often found feeding on the fruit of berries, and noticed that a small quantity of the fluid which this species exudes when disturbed caused a very pain-

ful sensation on a sore spot on his finger, almost like that produced by a burn.

During the last week of September two species of ants were noticed devouring apples on trees, some of the fruit having been almost completely devoured and badly honeycombed at the time.

October 6 *Euphoria inda*, the brown fruit-chafer, was observed feeding upon some apples that had been injured by ants.

UNUSUAL INJURY BY CUTTING ANTS IN TEXAS.

One of our correspondents, Mr. H. Booton, of Richmond, Tex., writes, under date of September 2, of very unusual injury by cutting ants in that State. As his letter is of unusual interest, we copy it entire:

Replying to yours of the 20th of August, in regard to the night ants, as you designate them, it is the same ant I refer to. We call them the cutting ants. In the lot next to me here in Richmond these ants undermined the wall to the city schoolhouse, causing the wall to fall. This same nest of ants destroyed 1½ acres of my orchard. I have gone down 10 feet after these ants. The school and county authorities sent to Galveston, Tex., for an architect to examine this house and give the cause of these walls falling, for which they paid this man $50. I was present when this man examined these walls. He pronounced them good walls—a sound foundation—the second best that can be made. He could not find the cause of the north wall falling. I offered him my assistance, which he accepted, and in five minutes I satisfied him that these ants had undermined this wall and were the cause of its falling. He so reported it and said it was the first wall in all his experience he had known to be destroyed by these cutting ants. I dug six holes, from 8 to 10 feet deep, in my yard for these ants. I smoked them with sulphur, which ran them under this brick house. The results I have stated. This nest of ants was destroyed or run away by the water running from the gutters off this house onto this nest after the wall had fallen. I use a buffalo blower to force the fumes of the sulphur into the holes of the ants. Bisulphide of carbon will not kill the cutting ants. It will kill the hill ants. These cutting ants will carry London purple and Paris green from 100 to 200 yards. I know of a well in this county which these ants destroyed by depositing London purple in it, and this well was nearly 200 yards from where these ants were fed on the London purple. I am the only man in this county who can kill these cutting ants.

INJURIOUS MOTHS ATTRACTED TO LIGHTS IN AUTUMN.

On the morning of September 23 the writer's attention was attracted to numerous individuals of the cotton moth (*Aletia argillacea* Hbn.) in the vicinity of electric-light globes in the business streets of Washington. The same species, together with the boll worm moth and other Noctuidae, were noticed at lights during the same evening, and the injurious forms predominated to such a degree that a tour was made of all available electric-light globes of the vicinity. From the captures an estimate was made and it was found that of the different species of moths attracted to the lights up to 11.30 p. m. about 85 per cent were injurious and the remainder innoxious. Other orders were conspicuous by their scarcity. A few common species of beetles, such as *Silpha*

surinamensis and Carabidæ, were found here and there occasionally, as also numerous gnats of no known importance, economically or otherwise. Outside of the Lepidoptera the only insect commonly seen was a chrysopa fly (*Chrysopa oculata*), a well-known beneficial species. The temperature at the time of collecting was about 65° on the streets, but the official reported temperature was 60°.

The list which follows of the species captured, and the percentage of their occurrence, both on the date of capture and an estimate of their occurrence during the week ending September 23, may be found of interest, not only as showing the value of lights in attracting injurious forms in autumn, but also for comparison with the list of insects captured in a cotton field near Victoria, Tex., October 1, 1897, which was published in Bulletin No. 18 (n. s., pages 85–88). Fully half of the species listed are Southern, *i. e.*, forms more frequently found in the South than in the Northern States. Anyone who has paid any attention to the species of insects attracted to lights in spring and summer can not have failed to have been struck with the fact that beneficial forms are frequently so abundant as to show in many cases that the lights are of practically no value whatever in reducing the numbers of destructive insects. Although the noxious forms outnumber the others, it must always be remembered that each individual of a predaceous or parasitic species during a lifetime is capable of destroying many individuals of the injurious species.

The following is the list of captures:

Latin name.	Common name.	September 23.	Week's average.
		Per cent.	*Per cent.*
Aletia argillacea	Cotton worm	26	5
Heliothis armiger	Corn ear worm, boll worm	9	16
Leucania unipuncta	Army worm	6	6
Laphygma frugiperda	Fall army worm	5	3
Crambus vulvivagellus	Vagabond crambus	12	12
Hypena scabra	Green clover worm	4	3
Plusia brassicæ	Cabbage looper	5	8
Feltia subgothica	Dingy cutworm	9	20
Agrotis ypsilon	Black cutworm	1	.....
Protoparce carolina	Tomato worm	1	2
Protoparce celeus	Tobacco worm	1	.....
Pyralis costalis	Clover hay worm	1	.....
Thyridopteryx ephemeræformis	Bagworm	1	.....
Plusia precationis	A cabbage looper	1	.....
Loxostege similalis	Garden webworm	2	4
Prodenia ornithogalli	Cotton cutworm	1	5
Miscellaneous injurious species		.....	6
Innoxious species of moths		15	10

—F. H. C.

THE ANGOUMOIS GRAIN MOTH IN PENNSYLVANIA.

It might be remembered by some of our correspondents that we made mention of the fact that the Angoumois grain moth (*Sitotroga cerealella* Ol.) is known to occur in the field as far north as Philadelphia, Pa. From accounts which have reached us this fall (1900), it is

evident that the extreme heat of the past summer induced numerous individuals of this species to fly northward, and it is also evident, from the numerous reports of injury, that the species is established outdoors, at least temporarily, in other localities than Philadelphia. Writing November 30, 1900, Mr. J. E. Walker states that this insect was ruining the wheat crop in the vicinity of Media, Pa. He writes that it can not be fanned out, as the hull or injured kernel and the insect are apparently so nearly of the same weight. In one instance men at work upon wheat were obliged to leave the barn at various intervals during the process of threshing to clear their throats and relieve their noses from the flying insects, which came in clouds, both dead and alive, from the machine. The presence of the insect in the grain was not discovered until threshing commenced, in November. Most of the wheat in that vicinity was threshed in July and sold, or complaints of injury would probably have been general.

Writing again January 23, our correspondent stated that after inquiry among persons residing in the neighboring towns he ascertained the extent of injury by this species to comprise a district radiating from Media and extending from Philadelphia to Newtown Square, to Westchester, to Kennett Square, to Ashland, Del., and up the Delaware River to Philadelphia, which completed the circuit. He expatiated on the difficulty of obtaining the information desired, owing to a general suspicion on the part of persons interviewed that the information which they might give would interfere with the sale of their farms; also that it was simply out of the question to endeavor to persuade farmers to apply remedies to grain that had been threshed. They were all willing to sell for what the grain might bring, and it was left to the middleman to do the "doctoring." Some interesting instances of infestation by this species were cited. One person owning a farm at Newtown Square threshed his grain from the mow, shipped 600 bushels to Philadelphia, and when the car was opened the next day the grain was so badly heated that a man walked on the top of it without making an impression with his shoe soles. Those who threshed immediately after harvest succeeded in effecting a sale of their wheat. A milling company at Kennett Square was refusing to take wheat for grinding, as several thousand bushels in stock was badly damaged before the presence of the moth was discovered. Another mill at Ashland, Del., was caught like the preceding. Six thousand bushels was damaged. Injury was general about Westchester, especially to wheat which was stored in the sheaf and permitted to remain some length of time before threshing.

February 6, 1901, we received information from a milling company of New York City that this species, specimens of which were sent, was very generally destructive throughout New Jersey and eastern Pennsylvania.

USE OF SULPHUR AS A REMEDY FOR THE INDIAN-MEAL MOTH.

Mr. A. Martin, Lamont, S. Dak., writes, under date of November 3, 1900, that during the summer of 1899 the Indian-meal moth (*Plodia interpunctella* Hbn.) became so numerous that he was obliged to have recourse to remedies. Having a hard-coal heater in the building in which the infested grain was stored, he decided to make an experiment. The first was to ascertain if coal gas and heat would have any effect on his unwelcome guests. Neither produced the desired result. On the contrary, the heat enabled the insects to multiply more rapidly, and the grain for a foot or so nearest the heater became quite hot—as high as 110° F.

Sulphur was tried, 3 pounds being burned in a couple of days, with result that it killed some of the moths, the fumes not being strong enough to effect the destruction of the larvæ. He next tried 3 pounds of sulphur, repeating with 3 pounds more. This killed all the moths not protected by being under boards or in similar localities. It did not affect the larvæ as far as could be seen. Our correspondent estimates that the moths could all be killed at an expense of about, say, 5 pounds of sulphur to 10,000 cubic feet.

Bisulphide of carbon cost, in this case, 25 cents a pound, and was therefore too expensive.

FULLER'S ROSE BEETLE IN THE HAWAIIAN ISLANDS.

Since writing on the so-called "olinda bug" (*Pandamorus olinda* Perk.), in "Notes on insects affecting the koa trees at Haiku Forest, Maui," specimens were given to me at San Francisco by Mr. Charles Fuchs, who claims that they were common in gardens of that city. Mr. E. A. Schwarz, to whom we showed specimens, pronounced them the well-known "Fuller's rose beetle" (*Aramigus fulleri* Horn). The insect has been figured in the Report of the Entomologist of the Department of Agriculture for 1879.[1] Dr. Riley states that as early as 1875 specimens were sent to him by Mr. A. S. Fuller, who found it in greenhouses somewhat injurious to camellias. In his report, Dr. Riley stated that "it seems to be quite widespread, occurring from the Atlantic at least as far west as Montana, and its habit of injuriously affecting roses and other greenhouse plants must be looked upon as a comparatively recent acquirement."

The so-called "Olinda bug" is found on Oahu, and lately occurred in destructive numbers at Kohala and Kau, on Hawaii. The injury of this beetle to trees is in reality not as serious as it would appear, and its presence upon older trees is barely noticed, while upon the young trees growing among the Hilo grass its presence is more apparent.

[1] More recently Mr. Chittenden has given an account of this species in Bul. 27, n. s., pp. 88–96.

We have seen many trees of the Java plum, recently planted, with every leaf eaten off, and some have died from the effects of the beetle and Hilo grass combined, while others again barely showed any sign of the beetle. Reports from Kohala state that the beetle also devours the bark of young trees. This we have never observed, but have no doubt of its accuracy where food is scarce. Most any plant or tree, and even the grass, is attacked by the beetle. The insect appears to be most numerous along the border of the forest, and it is found from the seashore up as high as 5,000 feet. Seven years ago we were shown the beetle at Paia, destructive to roses and garden plants in general. Mr. Perkins reports having some years since seen remains of the same at the base of koa trees near Olinda to a depth of several inches. It must have been present on the islands long before it became prominent, and it is likely an introduction from Mexico, and probably came from Acapulco.

The life history of the beetle is as yet but imperfectly known. Four years ago we found its larvæ under stones at Olinda, and collected large numbers of the same in all stages on this trip feeding on the roots of Hilo grass. We have obtained its eggs in confinement, deposited in clusters of some 75, of a light-yellow color, from three-fourths to 1^{mm}. long and half as wide. At the office we find that large numbers of young larvæ issue from galls produced by the Tortricid larvæ. Here the eggs are inserted anywhere where a hole is convenient, and are embedded in irregular masses partly covered by excremental remains. We should think that they are also found under the bark of trees on which the beetles feed. It was found that the large number of gall-like swellings on the terminal branches of the koa trees brought down for observation produced hundreds of young larvæ of the "Rose beetle." Whenever the galls showed any holes, or if partly split, they had been thrust full of eggs, often an inch or more in length. Doubtless this is done by several individuals when present in such enormous numbers as at Haiku. In gardens and small areas of land the beetles are easily dealt with, since they are wingless and can only crawl. They can readily be shaken off smaller trees into a bucket of water with a little kerosene and destroyed. This can be done at any time during the day or night while the beetles remain stationary upon the plants, where, if numerous, they will congregate in clusters.

Aramigus fulleri has not many enemies. The indigenous Carabid beetles on higher elevations must destroy many of their larvæ.

Insectivorous birds evidently feed largely upon the beetles. We found excrements of the mina or mynah bird consisting entirely of remains of these beetles. Quails are considered as excellent birds to destroy such insects; fowls should keep the surroundings of houses free of them. Probably some 90 per cent of the food of the mongoose

consists of insects, roaches, crickets, grasshoppers, and centipedes, and, from examination made, he also feeds upon the "Olinda bug."—ALBERT KOEBELE.

SINGULAR INSTANCES OF ATTACK ON HUMAN BEINGS BY INSECTS.

From time to time we are in receipt of specimens of insects from nearly every quarter of the globe with report that the species sent had caused annoyance by attacking men. In previous publications of this Department we have had occasion to mention more or less in detail the attacks and alleged attacks of the so-called "kissing bug," mosquitoes, fleas, bedbugs, and various other insects which are known to attack man habitually. Extreme cases, however, are constantly being reported, and some of these may be of interest. During December, 1900, we received a communication from Mr. F. D. Granger, of the United States Coast and Geodetic Survey, this city, with accompanying specimens of the ground beetle (*Harpalus erraticus*), a common species in the West, which had been taken in September of that year on the farm of Mr. William Lord, at Page, Nebr. Mr. Lord said he had never noticed the insects before that year, but remarked that they were "savage biters." Mr. Granger stated that personal experience proved the correctness of this assertion, and that not only he but other members of the party camped in that vicinity were bitten by these beetles.

EFFICIENCY OF THE TWO-SPOTTED LADYBIRD AS A PLANT-LOUSE DESTROYER.

During the latter part of June Mr. J. J. Newbaker, Steelton, Pa., and Mr. M. P. Jones, Morristown, N. J., sent specimens of the cherry aphis (*Myzus cerasi*) and of the apple louse (*Aphis mali*) on peach and apple, respectively, in both cases with accompanying specimens of the two-spotted ladybird (*Adalia bipunctata*) in the pupal condition when received. The pupæ were found in groups of half a dozen and more within the curled-up leaves, and in neither case were any plant lice remaining, the larvæ having devoured them all before transforming. It seems probable that a similar condition of affairs existed in both localities upon the trees.

THE "OVERFLOW BUG" AGAIN.

October 15, 1900, Mr. J. Hardy, Milton, Cal., sent specimens of the ground beetle *Platynus maculicollis*, known in California as the "overflow bug" or "grease bug," with report that the species was a very annoying pest in that vicinity at that time of the year. Our correspondent writes:

> They make their appearance about dusk, within three or four days after the rain, and remain from ten days to three weeks. They enter the houses in great numbers and get into everything. If disturbed they emit a strong fetid stifling odor.

They enter the best built houses, which other pests never enter, nor does cleanliness about the premises or location on high or low ground seem to make any difference. * * * They will walk off of sticky paper, and "buhach" does not affect them. To give you some idea of how they run over us, I will say that I can at this time (8 p. m.) count over 50 crawling over a small table, about 1½ by 3 feet, in front of me.

A letter from the pen of Mrs. A. E. Bush, one of our California correspondents, was published concerning this insect in the American Naturalist of August, 1882 (pp. 681, 682), and we published a brief note from correspondence with Mr. A. A. Eaton, Riverside, Cal., in Insect Life, Volume V, page 342. This beetle is a Carabid, and, like most species of this family, may be predaceous. A number of the beetles were confined in a small box and sent to us by Mr. Hardy, and nearly all reached this city in good condition, a very unusual state of affairs when it is considered that they were in such close confinement and had nothing to feed upon. Even one beetle that died did not appear to have been attacked by its fellow prisoners. Possibly the disagreeable odor emitted by the beetles may have an effect in deterring others from attack.

A REMEDY FOR FLEA-BEETLES IN CALIFORNIA VINEYARDS.

We are in receipt of a communication from Mr. E. H. Twight, San Francisco, Cal., dated May 15, 1901, in which he states that flea-beetles do great damage in California at times, and that if the pests are not too numerous they can be fought with a flat with a slot to fit around the trunk of the vine, ending in a bag. When this is used early in the day, before it becomes too warm, the insects drop in with a slight shake of the vine. A man is supposed to treat 200 vines in an hour. When the bag is full it is dipped in hot water and the insects fed to chickens.

When the flea-beetles appear regularly every season, our correspondent states, it is desirable to keep the vineyard free of weeds, bushes, dirt, and other accumulations, and in fall place some artificial shelters, such as stray covers, about the vineyard on the ground, so that these can be burned in winter when the pest seeks them as a shelter in which to hibernate.

INJURY TO RUSTIC CEDAR FENCES AND SUMMERHOUSES BY BORERS.

May 24, 1900, Mr. J. Harold Austin, Lansdowne, Pa., complained of injury by *Callidium janthinum* Lec., judging by his description, to a small rustic cabin, built of red cedar, at that place. During the past five years injury by *C. janthinum* and some few other borers has been noticed by the writer to fences and summerhouses and other rustic buildings in many suburban homes and public resorts in the vicinity of Washington, D. C. This borer, with *Hylotrupes ligneus*

Fab., was by far the most numerous, but other insects assist somewhat in the injury, among them *Atimia confusa* Say. The first or second year after the borers have begun work the woodwork is greatly marred by the exit holes which are left in the bark.

May 13, 1901, we received information from Dr. R. H. Lawton, together with accompanying specimens, that *Hylotrupes ligneus* was the cause of considerable trouble in the cedars in his vicinity. March 30 the beetles made their appearance in an office in that town and were very plentiful until the middle of April, when they disappeared. Dr. Lawton found in a basement a pile of cedar sticks from which the insects had emerged. The sticks were badly damaged and fully accounted for the number of the beetles.

There seems to be no practical remedy when cedar wood is used for outdoor ornamental purposes. If it were kept indoors for a season or more and saturated in April and May with gasoline, or some similar preparation, it might be kept free from infestation and in time the wood would be so dry that the borers would not attack it.—F. H. C.

INEFFECTIVENESS OF KEROSENE EMULSION AGAINST WHITE GRUBS.

One of the remedies which has been frequently suggested as of value against white grubs is the kerosene emulsion. Its use has been advised in various publications and in the correspondence of this Division.

Kerosene emulsion diluted with 15 parts of water, applied to celery by Mr. Lull, formerly of this Division, in 1893, did not injure the plants, but killed the larvæ of *Allorhina nitida* which were at or near the surface of the ground, but apparently failed entirely to reach such larvæ as were at a depth of two inches or more beneath the surface. This matter was brought to the attention of the public in Bulletin No. 10, in an article by Dr. Howard (p. 25).

Mr. W. K. Shaw, acting upon our suggestion, tried kerosene emulsion against larvæ of Lachnosterna, presumably *Lachnosterna fusca*, the common white grub of Massachusetts, in the vicinity of Boston. He was at first of the opinion that it killed the small grubs but did not affect the larger ones. Later he could not see that the most careful use of this emulsion was effective against these white grubs.

There is no doubt about the strength of the emulsion, as Mr. Shaw is a graduate of the Massachusetts Institute of Technology, and directions for the preparation and application of this insecticide were followed implicitly, the ground having been thoroughly soaked, and in each case followed by an effective rain to wash the kerosene more thoroughly into the ground.

A NEW ENEMY TO FIGS IN MEXICO.

Dr. Edward Palmer, when visiting Parras, in the State of Coahuila, Mexico, in the midsummer of 1898, was surprised to notice the destruction of the fig crop by an insect he had not known before to be injurious to that fruit. He saw in the different gardens trees loaded with figs in the various stages of ripening. Under the trees were many which had fallen, and which were dry and hard. Little plant bugs were noticed attacking the fruit as soon as it began to be soft and sweet. They inserted their beaks and sucked until all of the sweet moisture was extracted. The trees were covered with fruit in all stages of destruction, and the dried fruit on the ground showed the end of the whole crop.

The fig was of the blue-black kind, a very prolific bearer, and quite sweet. There were no figs in the market, and the crop in that vicinity was practically destroyed.

Dr. Palmer brought home specimens of the insect, but all were, unfortunately, immature. Mr. O. Heidemann examined them and found that they belonged to a species of Pyrrhocoridæ, coming nearest to *Stenomacra marginella* H. S.

ON THE FOOD HABITS OF THE PAPABOTTE.

Mr. G. H. Ellwanger, Rochester, N. Y., writes us under date of November 25 concerning food habits of the papabotte, which is Creole French for Bartram's sandpiper, a bird somewhat more commonly known as the field, grass, or upland plover, which frequents our pastures and feeds on grasshoppers, crickets, and other insects. According to our correspondent, this bird appears in Louisiana and Texas in large numbers about the middle of July, remaining until the latter part of September. Simultaneously with the advent of a species of "Spanish fly," which also appears in great numbers, and which eats ravenously of various growing things. The papabotte feeds upon this insect and becomes very fat, acquiring a peculiar and very high flavor. But the flesh of the bird as a result of this diet is said to be sometimes poisonous, and also to be highly aphrodisiacal in its effects. A steward of one of the New Orleans clubs is quoted as stating that he found twenty-six of these Spanish flies in the stomach of a dozen birds examined.

As there are upward of a score of common species of Meloidæ, or Spanish flies, better known as blister beetles in portions of Texas, and nearly all of these become periodically very numerous and destructive, it is impossible to specify the insect or insects preferred as a food by this bird.

ON THE INSECTIVOROUS HABITS OF SQUIRRELS.

In writing of the natural enemies of *Catocala maestosa*, the larvæ of which were observed to be injuring the foliage of pecan at Biloxi, Miss., Mr. James Brodie makes statement under date of June 19 that squirrels destroy these insects. June 28, he says his attention was called by his little girl to squirrels eating these caterpillars. At first he doubted, but watched and saw that it was as the child reported. One of the squirrels was partially tame and took nuts from his hand. A caterpillar was handed to this squirrel and it was eaten. In devouring a caterpillar the squirrel would take it in its paws, pull off the head and throw it away, while the viscera were expelled or drawn out and rejected, only the skin being eaten. Mr. Brodie also stated that the squirrels were fond of fungi. The squirrels observed eating insects were the common gray squirrel and the flying squirrel. One was observed devouring a large longicorn beetle, which was placed near it for the purpose.

INSECT INJURY TO BINDING TWINE.

We have received several complaints of injury by crickets and grasshoppers to binding or binder twine, which we are informed is used for stacking small grain in the field, a remedy or preventive being desired. During May, 1901, Mr. I. D. Sheaffer, Russell, Kans., and Miss Annette Bowman, Moscow, Idaho, wrote in regard to such injury. These are only two of several complaints. In no cases have we received specimens of the insects, nor have we been able to suggest any substance that would kill the insects or deter them from attacking the twine that would not at the same time be dangerous to those handling it. Poisons, of course, could not be used, and sticky substances would also be objectionable, although, of course, they would prevent injury by the insects.

TO RID CATS OF FLEAS.

The following from a New York paper adds something new to our knowledge of the means of ridding domestic animals of fleas. This method would probably be equally effective in ridding small dogs and puppies of fleas.

An excellent way to get rid of fleas is used by a lady in Chicago, who owns some of the best cats in America. She has ready a square of cotton batting and a square of cotton cloth, placing the cat in the center of the batting, which has been laid over the cloth; she rubs strong spirits of camphor quickly into the fur and then gathers the corners of the batting and cloth tight around the neck of the animal. She has a fine comb ready and a dish of hot water, for the pests, who detest the camphor, will run to the head of the cat, and must be combed out and plunged into the scalding water. Hundreds of them, however, will jump from the cat and lodge in the cotton batting, where their scaly feet stick in the cotton so that they can not get away.

When the fleas cease to run out onto the head of the cat she judges that they have deserted the cat. The animal is then let out of the batting bag, and the latter carefully carried to the kitchen and deposited in the stove. The scent of the camphor clings to the cat for some time and acts as a preventive. A whole cattery may be cleaned out in this way.

A NEW REMEDY AGAINST PHYLLOXERA.

Professor Vassiliere, in the Gironde, France, has for several years past met with good success in using calcium carbide against phylloxera.

It is said to be superior for this purpose to bisulphide of carbon, both as to efficiency and absence of danger in handling. The cost also is less and it can be used in any season. It is sufficient to use the residue resulting from the manufacture of carbide of calcium, which is of little value otherwise and which is sold at about $2 for 220 pounds.

For 1 hectare of vineyard land (1 hectare equivalent to 2.471 acres) about 1,100 pounds of carbide are required. The carbide pieces are put into holes in the ground, about 8 inches deep; water is poured in and the hole filled up again. The resulting vapors kill the phylloxera, while the ammonia generated manures the ground. Carbide is at present extensively used in the vineyards of southern France, and experts claim that it is the best remedy against phylloxera.—Richard Guenther, consul-general, Frankfort, Germany, May 28, 1901.

A NOTE ON THE GLASSY-WINGED SHARPSHOOTER.

(*Homalodisca coagulata* Say.)

Mr. W. D. Hunter, special agent of this Division, while at Victoria, Tex., during May, 1901, wrote us on the 29th as follows concerning this insect, specimens of which he sent, and which he stated were feeding upon planted banana trees in great numbers:

These insects feed upon the upper surface of the leaves and seem to prefer the cavity of the midrib, or that immediate vicinity, for their operations. I notice what was to me an interesting habit of these insects. While feeding during the portion of the day when the sun falls hottest upon the leaves of the plant, each one is continually, at intervals of only a few seconds, ejecting drops of liquid apparently from the anal aperture. These drops are large enough to be seen plainly at a distance of 15 feet and are forced out with such vigor that they go often as much as 12 inches in a straight line before beginning to fall. Where there are many of the insects upon a leaf a miniature rainfall is produced. Such a forcible ejection of honeydew, and in the case of insects outside of the Aphididæ or Ceropidæ, seems remarkable to me and may be of interest to you.

ON THE ALLEGED IMMUNITY OF REDWOOD TO ATTACK BY TERMITES.

December 13, 1900, we received a communication through a firm of lumber merchants of San Francisco, Cal., which appears to indicate that the California redwood lumber is immune to the attack of white ants, or termites. Through the firm in question we received a letter

from Mr. J. E. Norton, dated December 4, relating to the resistance of this wood to the so-called Manila white ant or Annia. His letter is in substance as follows:

In the latter part of 1898 I secured from a transport a piece of redwood board about 12 inches in length, which was placed beneath a pile of lumber in a yard at Manila. The spot was damp, and various pieces of timber all around showed evidence of the existence of the ant in abundance. This piece lay undisturbed for a period of five or six months, and when examined was found as sound as when put there, not having been attacked by any insects. The Chinaman, owner of the lumber yard, was still doubtful, and undertook to get it eaten by putting it in different places under different conditions, such as on top of pieces already inhabited, between boards, and underneath piles, and finally, after three months, put the sample on exhibition in his office with the following placard: "Madera Colorado de California, no se comen Annai."

The quartermaster's lumber yard had piled for some four or five months a quantity of redwood, which upon my departure in October was still free from ants.

John MacLeod, of Manila, has a room in one of his houses finished in redwood, constructed over fifteen years ago, and to this day three-fourths of the original amount remains still in good condition, one-fourth having been worn out and replaced by other lumber.

THE BRAN-ARSENIC MASH AGAINST GRASSHOPPERS IN TEXAS.

One of our correspondents, Mr. S. D. Harwell, Putnam, Callahan County, Tex., writes as follows in regard to the successful use of bran arsenic mash as a remedy for grasshoppers in Texas:

We are successfully using arsenic (for grasshoppers) at the following rates: 10 pounds wheat bran, 1½ gallons sorghum molasses, 1 pound arsenic. Make a thick mash, sow broadcast on infected ground, and it will surely kill them. I used 40 pounds last year and made 49 bales cotton. My neighbors did not do anything and entirely lost their crop.

TERMITES IN MEXICO.

We received during August, 1900, from Prof. A. L. Herrera, chief of the commission of parasitology, Condensa 4½, Mexico, D. F., Mexico, specimens of *Calotermes castaneus* Burm., a species widespread and commonly known in Mexico as "Palomilla de San Juan" (St. John's Dove). It is so named from the belief that it puts in its first appearance on St. John's day (June 24). It attacks wood and causes serious injury. Two hundred were collected in one room, attracted by a light placed in a vessel containing water. The insects fell into the latter and were drowned.

AN ENTOMOLOGICAL SERVICE IN MEXICO.

The Mexican Government proposes to start work in economic entomology under official auspices at an early date. Prof. A. L. Herrera, at present zoologist in the Museo Nacional, is to be "jefe efectivo," and Mr. O. W. Barrett is to be first assistant. The first work will be an investigation of the distribution of the Mexican orange worm (*Trypeta ludens*) and the best measures to be used against it.

NOTES FROM CORRESPONDENCE.

Remedies against ants.—Mr. J. B. Blandy, of Funchal, Madeira, writes that the following remedy is used in houses in Funchal against ants: Tartar emetic, 10 grams; white sugar, 100 grams; water, 1,000 grams. Mix the sugar and water well and put on the fire until it boils, then let it cool, add the tartar emetic and dissolve it equally. Set about in tins or other receptacles covered with wire netting for fear of injuring cats or dogs.

Mrs. Conklin, Perris, Cal., writes under date of October 27, 1900, that in her experience an application of corrosive sublimate applied with a brush to the edges, back, sides, and crevices of shelves in what is known as an adobe cool room, vanished ants for an entire season. Nests in gardens were destroyed with bisulphide of carbon, as recommended by this Division in Bulletin No. 4, on household insects, and Circular No. 34.

A troublesome ant.—Mr. John F. Wielandy, a fruit grower of Santa Fe, N. Mex., and an old correspondent of this Division, wrote under date of June 14, 1900, that a red ant, known as *Pogonomyrmex barbatus*, specimens of which were inclosed, was a most pugnacious and ill-natured insect; that its bite was far more painful to many persons than the sting of a bee or hornet. It is locally known as fire ant, and has never been known to foster aphids, as is the case with so many other species of ants.

Migration of the Western willow flea-beetle.—Concerning the flea-beetle, *Disonycha quinquevittata*, of which Mr. Herbert Brown, Yuma, Ariz., wrote some months ago (see Bulletin No. 18, n. s., p. 100), our correspondent writes under date of December 21, 1899, that these beetles were again observed migrating in that year, this time coming down the Gila River and going in the direction of the Colorado. They moved November 3 and 4 in a belt apparently not more than 100 yards wide, and continued doing so during the two days mentioned. When observed they were usually flying about 4 feet above the earth and never more than about 20 feet high.

The grapevine Fidia in Illinois.—Writing May 11, 1900, Mr. J. L. Lampe, jr., Bloomington, McLean County, Ill., states that the grapevine Fidia (*Fidia viticida* Walsh.) in his part of the State had done serious injury to vineyards. Damage was attributed by many growers to the severe winter of 1898 to 1899, which they thought killed the vines, but our correspondent was certain that this was a mistaken idea and that the vineyards were in reality ruined by this beetle, as he had observed conditions closely and had been in correspondence with Mr. F. M. Webster, of the Ohio experiment station. What was left of his once fine vineyard he stated he would experiment on with arsenate of lead, other insecticides seeming to have no effect.

Beetles occurring about smelting works.—October 18, 1900, Mr. Carroll Fowler, of the agricultural experiment station at Berkeley, Cal., sent specimens of the Buprestid beetles, *Melanophila longipes* Say and *M. consputa* Lec., with the accompanying information that they were reported to him to have been collected at Calaveras, Cal., September 2 of that year, in the immediate neighborhood of smelting works. These beetles were said to rest frequently on the hot slag and appeared to delight in the fumes of the smelting works.

A snout-beetle injuring guava in Porto Rico.—Writing July 30, 1900, Mr. J. W. Van Leenhoff sent specimens of the snout beetle *Diaprepes abbreviatus* with the information that they were met with in considerable numbers attacking the young plants of guava grown for shade, and according to report were attacking also young coffee plants. The young plants of guava were eaten bare of their leaves. They were kept in subjection by hand picking, the beetles as fast as caught being placed in a wide-mouthed bottle and afterwards burned.

This beetle is a rather striking species and plainly exotic from its appearance, not being known to occur in the United States. It measures, with the short snout,

upward of half an inch in length, is black in color, with pale yellow elytra striped with black, and a yellow spot on each side of the thorax.

Reported injury by the oil beetle, Meloë impressus Kirby.—January 12, 1900, Miss Mary E. Murtfeldt, Kirkwood, Mo., sent a specimen of this species with the statement that it had been received from a correspondent in Missouri, with report that it was "eating wheat and rye to the ground in patches from the size of a dinner plate to that of a table, right through frost and sleet, as though nothing was wrong." The determination of the species is by comparison with specimens in the national collection. When this genus Meloë is given further study it may possibly prove to be a distinct form. Various species of Meloë are known to appear above ground during mild days in winter and early spring, and whenever they appear they usually occur in numbers.

Injury to apple leaves by the caterpillar of Euclea pænulata Clem.—August 15 Mr. H. G. Mitchell sent the beautiful larvæ of this limacodid moth with report that they were destroying the leaves of apple trees at Tuscaloosa, Ala. This insect is a well-known enemy of willow and its occurrence on apple is noteworthy.

Injury by Lygus invitus Say.—June 19, 1901, we received through Mr. E. S. Goff from Mr. W. T. Innis, Ripon, Wis., specimens of *Lygus invitus* Say, a near relative of the tarnished plant-bug (*Lygus pratensis*), with report that this bug was destructive to peaches last season in that vicinity. The bug evidently sucked the juices from the young fruits, causing them to shrivel and perish. This is the first instance of injury by this species with which we are at present acquainted.

The box-elder plant-bug (Leptocoris trivittatus Say) in Iowa.—April 8, 1901, Mr. J. H. Hill, Elkader, Iowa, sent specimens of this bug, with accompanying information that it made its appearance in that vicinity about four years ago, and although apparently harmless it had so increased in numbers as to have become an intolerable nuisance indoors. During warm weather the bugs inhabited the trees, but on the approach of winter they would creep into houses or wherever they could find shelter. At the time of writing, the county court-house resembled a beehive, inside and out.

A European plant-louse introduced in Massachusetts.—June 22, 1900, Mr. Samuel R. Thompson, Globe Village, Worcester County, Mass., wrote from Sturbridge, of the same State, transmitting specimens of twigs of peach infested with *Aphis persicæ* Koch.

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